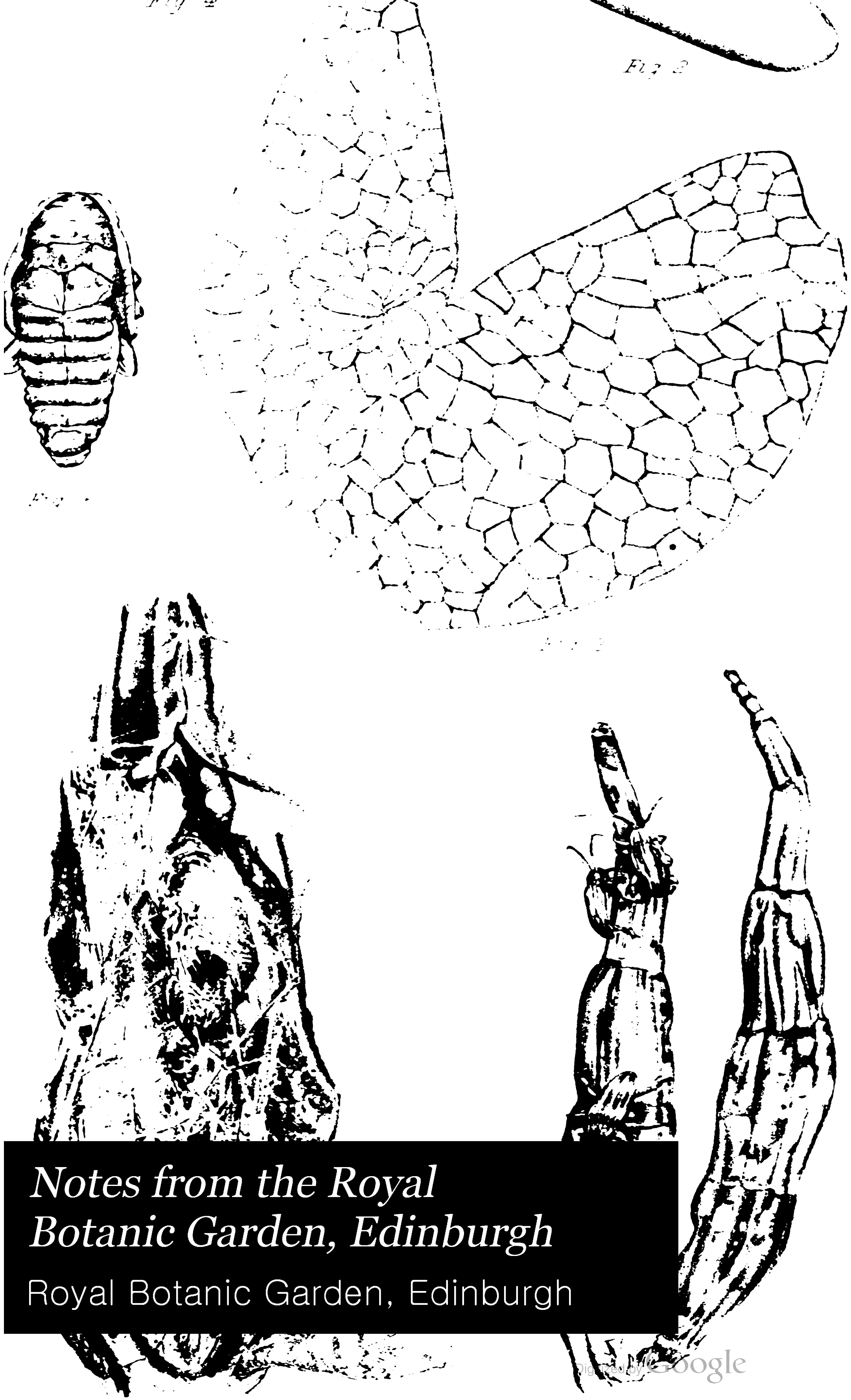

# Notes from the Royal Botanic Garden, Edinburgh

Royal Botanic Garden, Edinburgh

# NOTES

FROM THE

# ROYAL BOTANIC GARDEN,

# EDINBURGH.

**VOL. I.**

**Including Numbers I.-V.**

**1900-1901.**

GLASGOW:
PRINTED FOR HIS MAJESTY'S STATIONERY OFFICE
By JAMES HEDDERWICK & SONS,
AT "THE CITIZEN" PRESS, ST. VINCENT PLACE.

**SOLD AT THE GARDEN,**
And to be purchased, either directly or through any Bookseller, from
OLIVER & BOYD, EDINBURGH.

## Dates of the several Numbers of this Volume.

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Part I., pp. 1-24 for January, 1900.
Part II., pp. 25-40 for November, 1900.
Part III., pp. 41-134 for December, 1900.
Part IV., pp. 135-192 for August, 1901.
Part V., pp. 193-246 for December, 1901.

# List of Contents to Vol. I., 1900-1901.

# NOTES

FROM THE

# ROYAL BOTANIC GARDEN, EDINBURGH.

JANUARY 1900.

CONTENTS.



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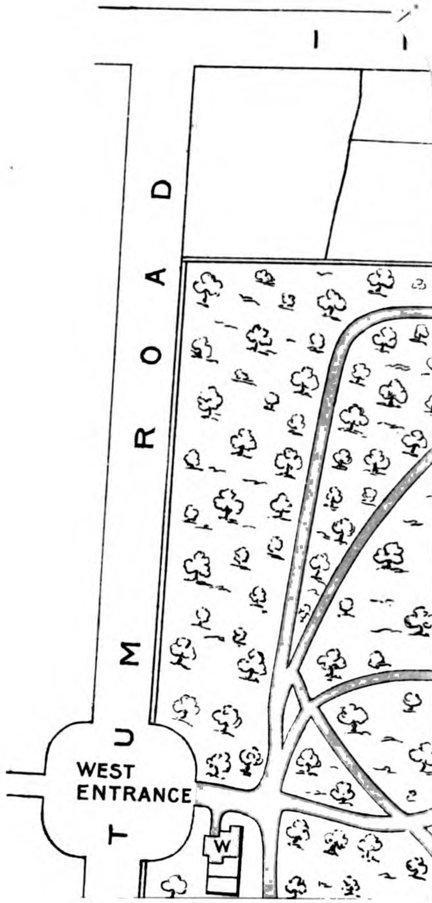
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# NOTES FROM THE ROYAL BOTANIC GARDEN, EDINBURGH.

It is proposed to issue from time to time, under the title of "Notes from the Royal Botanic Garden, Edinburgh," reports upon the condition and progress of the Garden, records of scientific investigations carried on in the Garden, and notices of points of interest relating to plant-life which come under the observation of the Staff. To this first number there is prefixed a brief notice of the Botanic Garden itself.

The "Notes" will be available in exchange for publications of kindred institutions, and will also be on sale to the public.

ISAAC BAYLEY BALFOUR,
*Regius Keeper.*

*January*, 1900.

# THE ROYAL BOTANIC GARDEN, EDINBURGH.

THE Royal Botanic Garden, Edinburgh, is one of the three Gardens maintained by the State in the United Kingdom, the others being the Royal Gardens at Kew in England, and the Glasnevin Garden at Dublin in Ireland. It occupies an unequally-sided quadrilateral area of 57·648 acres (bounded upon all sides by public roads and dwelling-houses) on the North side of Edinburgh—about a mile from the shore of the Firth of Forth. Its highest point, at Inverleith House (**R**)—the official residence of the Regius Keeper of the Garden—towards the
107 North-west, is [illegible] feet above sea-level, and thence the ground falls
away on all sides. The lowest point—a depression [illegible] feet above 48
sea-level, with an east and west trend through the middle of the Garden—is the site of an old bog, and the ground rises again to the south of the depression. The surface soil is generally alluvial sand resting on clay at considerable depth. In the lower part of the area the clay comes to the surface.

There are two entrances—one upon the east side from Inverleith Row into the Garden, the other upon the west side from Arboretum Road into the Arboretum. The Garden is open daily from 8 a.m. on Week-days and from 11 a.m. on Sundays until sunset. The Plant-Houses are open from 1 p.m. until 5.30 p.m., or until sunset if this be earlier. The Museum is open on Week-days from 10 a.m. until 6 p.m., on Sundays from 1 p.m. until 5.30 p.m. The Herbarium and Library are open on Week-days from 10 a.m. until 6 p.m., excepting on Saturday, when they are open until 1 p.m.

## Staff of the Royal Botanic Garden, Edinburgh.

---

| | |
|---|---|
| Regius Keeper, . . . . | Isaac Bayley Balfour, M.A., M.D., F.R.S. |
| Assistant in Museum, . . | Harry Frank Tagg, F.L.S. |
| Assistant in Herbarium, . . . | John Frederick Jeffrey. |
| Clerk, . . . . . . . | Henry Hastings. |
| Head Gardener, . . . . | Adam Dewar Richardson. |
| Assistant Head Gardener, . . . | Robert Lewis Harrow. |
| Foreman of Herbaceous Department, | William Henry Waite. |

**RULES for the Royal Botanic Garden and Arboretum in connection with the Regulations prescribed by "The Parks Regulation Act, 1872."**

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1. No unauthorised Person may ride or drive in this Garden or in the Arboretum, and no Wheelbarrow, Truck, Bath-chair, Perambulator, Cycle, or other Vehicle or Machine, is allowed to enter, except with the written permission of the Keeper. Children under ten years of age are not admitted unless accompanied by a Parent or suitable Guardian.

2. No Horses, Cattle, Sheep, or Pigs are allowed to enter.

3. No Dogs are admitted.

4. No Bags, Baskets, or Parcels, no Flowers, and no implements for Games may be brought in; Artists and Photographers may not bring in their Apparatus without written permission from the Keeper.

NOTE.—*The foregoing Rules shall not apply to persons going to or leaving Inverleith House by the road leading from the Arboretum Road Gate to the House.*

5. Visitors are to enter and leave the Plant Houses by the Doors according to the Notices affixed thereon.

6. Smoking is not allowed in the Plant Houses.

7. No Person shall touch the Plants or Flowers.

8. Pic-nics and luncheon parties are not allowed.

9. No unauthorised Person shall Drill or practise Military Evolutions or use Arms or play any Game or Music, or practise Gymnastics, or sell or let any Commodity.

10. No unauthorised Public Address may be delivered in the Garden or Arboretum. No Performance or Representation either spoken or in dumb show shall be given in any part of the Garden or Arboretum, unless by permission of the Commissioners

of Her Majesty's Works and Public Buildings. No Person shall use any obscene, indecent, or blasphemous words, expressions, or gestures, or do any act calculated to provoke a breach of the Peace, in the course of, or in connexion with, any speech, address, performance, recitation, or representation. No money shall be solicited or collected in connexion with any performance, recitation, or representation, except by permission of the Commissioners of Her Majesty's Works and Public Buildings.

11. Large parties must be broken up to prevent crowding.

12. Climbing the Trees, Railings, or Fences is forbidden.

13. Birds' nesting, and taking, destroying, or injuring Birds or Animals are forbidden.

14. The distribution of Handbills, Advertisements, and other Papers by the Public is forbidden.

Dated the 4th day of August 1896.

*Sealed with the Common Seal of the Commissioners of Her Majesty's Works and Public Buildings.*

REGINALD B. BRETT,
Secretary.

*Seal*

## Historic Notice.

IN the year 1670 a portion of the Royal Garden around Holyrood House was occupied by two eminent Edinburgh physicians, Andrew Balfour and Robert Sibbald, for the making of a Physic Garden, and James Sutherland was appointed to the "Care of the Garden." This was the foundation of the Royal Botanic Garden of Edinburgh, which is therefore, after that of Oxford (founded in 1632), the oldest in Great Britain. The stocking of the Garden with plants was effected from the private Garden of Dr. Andrew Balfour, in which for some years he had been accumulating medicinal plants, and also in great measure from that at Livingston in West Lothian, the laird of which, Patrick Murray, was much interested in the growing of useful plants.

In 1676 the same physicians acquired from the Town Council of Edinburgh a lease of the Garden of Trinity Hospital and adjacent ground for the purpose of a Physic Garden in addition to the Garden already existing at Holyrood, and they appointed the same James Sutherland to be "Intendant" of this Garden. The site of this Garden, which for convenience of reference may be called the Town's Botanic Garden, was the ground lying between the base of that portion of the Calton Hill upon which the prison is built and the North Bridge, and it is now occupied by a portion of the Waverley Station of the North British Railway. The name Physic Garden attached to a street in the vicinity is a reminiscence of the existence of the Garden at this spot.

About 1702 another Botanic Garden was established in Edinburgh in the ground immediately adjacent to the College Buildings, apparently on the site of the present South College Street. This was the College Garden, and of it James Sutherland became also custodian.

Thus in the early years of the eighteenth century there were in Edinburgh no less than three distinct Botanic or Physic Gardens—one at Holyrood, the Royal Garden; one around Trinity Hospital, the Town's Garden; and one beside the College, the College Garden. All these were at first under the care of James Sutherland.

Sutherland from the first made use of the Royal Garden for giving "instruction in Botany to the Lieges," and received a royal warrant appointing him Botanist to the King in Scotland, and empowering him to "set up a Profession of Botany" in this Garden. When the Town's Garden was created the Town Council appointed him to lecture on Botany as Professor in the Town's College, now the University of Edinburgh. In 1683 he published his "Hortus Medicus Edinburgensis, or a Catalogue of the Plants in the Physical Garden at Edinburgh," from which and from other published notices of the Town's Garden we learn that between two and three thousand plants were in cultivation. There is no means of determining how these plants were distributed between the several Gardens at the date of publication of Sutherland's catalogue.

In 1706 Sutherland resigned the care of the Town's Garden and the College Garden as well as his Professorship in the University, but, remaining King's Botanist, he retained the care of the Royal Garden at Holyrood. Charles Preston was appointed his successor by the Town Council, and there were thus established rival Gardens and rival Professors of Botany in Edinburgh. Charles Preston died in 1712, and was succeeded in his offices by his brother George Preston. Neither of the Prestons had ever the care of the Royal Garden.

In 1715 Sutherland died, and his successor as King's Botanist, Keeper of the Royal Garden, and Regius Professor of Botany was William Arthur, who, however, for political reasons did not hold the offices long, and was succeeded in 1716 by Charles Alston.

In 1724 the College Garden, having fallen into disorder, was turned to other uses; and in 1729, George Preston having retired, the Town Council appointed, as his successor in the charge of the Town's Garden and as Professor of Botany in the University, Charles Alston, who as King's Botanist had already

the charge of the Royal Garden and was Regius Professor of Botany. Through him, after separation for a quarter of a century, the Royal Garden and the Town's Garden were again combined under one Keeper, and the Regius Professorship of Botany and the University Professorship were similarly united. They have so continued to the present time.

In 1763, the Royal Garden and the Town's Garden proving too small and otherwise unsatisfactory, John Hope, who had succeeded Alston in his offices in 1761, proposed a transference of the two to a more congenial site in which they could be combined. At first it was intended to secure ground to the south of George Watson's Hospital—the area upon which much of the present Royal Infirmary is built—but this not being possible, five acres of ground on the north side of Leith Walk, below the site now occupied by Haddington Place, were chosen. As Hope proposed to transfer the collections in the Royal Garden to the new Garden he was able to secure the support of the Treasury to his scheme, and the selected ground was leased in name of the Barons of Exchequer. At the same time the Town Council agreed to contribute £25 annually to the support of the Garden, this sum being the amount of rent expected from the letting of the old Town's Garden. The plants from both Gardens were transferred to the ground at Leith Walk, and from this date there has been only one Botanic Garden in Edinburgh.

The site thus secured for the Garden proved, however, only a temporary one. Daniel Rutherford, who in 1786 succeeded Hope in his offices, cast about him for a spot in which more ground would be available for the extension of the Garden ; and eventually in 1815 nine and a half acres of the land lying to the east of Holyrood Palace, and forming the ground of Belleville or Clockmill, was fixed upon as a site in every way desirable ; but Rutherford dying before completion of the arrangements for the transference of the Garden, his successor, Robert Graham, appointed in 1820, preferred the more open site of the Inverleith property which the Garden now occupies, and fourteen acres of the Field or Park of Inverleith, known as Broompark and Quacaplesink, were purchased by the Barons of Exchequer from Mr. James Rocheid, its owner, in 1820, the lease of the Leith Walk

Ground being sold. By 1823 all the plants had been transferred to the new Garden.

In 1858, during the Keepership of John Hutton Balfour, who succeeded Graham in 1845, a further addition, by purchase from the proprietor of Inverleith, of a narrow belt of two and a half acres was made to the Garden on the west side; and in 1865, the Caledonian Horticultural Society having resigned to the Crown its lease of the ten acres of adjoining ground which it had occupied since 1824 as an experimental Garden, this ground was also made part of the Botanic Garden. Finally the present area of the Garden was completed in 1876, when the Town Council purchased from the Fettes Trustees twenty-seven and three-quarter acres of the Inverleith property on the west side of the Garden and transferred it to the Crown for the purpose of making an Arboretum in connection with the Garden; the Crown at the same time purchased Inverleith House and two and a half acres of additional ground.

In 1879, on Balfour's retirement, Alexander Dickson became Queen's Botanist, Regius Keeper and Professor, and held these appointments until his death in 1887. During his term of office the Arboretum was thrown open to the public.

Surrounded as it now is on all sides by public roads, no further extension of the Garden upon its present site can be made.

## Features of the Garden.

The method through which the Garden was built up by successive additions resulted in an absence of combination between its several parts, in great measure a consequence of want of adequate funds to make the necessary alterations in the grounds. During the past decade, in which the Garden has been wholly under the administration of the Commissioners of H.M. Works, the bringing about of this combination has been in progress. The work is not yet completed, and the Plan of the Garden which is attached to this sketch shows the area of the Garden as it is laid out at this date—January, 1900. Future editions will show further changes as the work of reconstruction proceeds.

From its foundation the Botanic Garden has been devoted to the teaching of Botany, and its usefulness in this respect has determined the laying out of its area.

**Herbaceous Garden.**—A considerable space is occupied by a collection of herbaceous plants arranged for study in natural orders after the "Genera Plantarum" of Bentham and Hooker.

**Rock Garden.**—There is an extensive rockwork upon which alpine and rarer herbaceous plants are cultivated.

**Arboretum.**—The whole of the western area of the Garden will be eventually utilised as an Arboretum of trees and shrubs, with the exception of the Conifers, which are now placed in the ground adjacent to the Rock Garden.

The **Plant-Houses** are still in process of reconstruction. So far as they have been rearranged at the present time they consist of a long range to the north of the herbaceous collection, composed of a Central Green-house, from the sides of which two Corridors run east and west (**H**). In the Entrance Porch to the Central Green-house is a collection of Insectivorous Plants (**I**). From the Eastern Corridor two houses project to the south—one occupied by Plants of Dry Regions (**F**), the other containing

Economic Plants of both Tropical and Temperate Regions (**G**). The House terminating the Eastern end of this Corridor is one of the old and decayed plant-houses, to which visitors are not admitted pending its reconstruction. To the south side of the Western Corridor are attached two houses—one for Orchids (**J**) and one for Plants of Tropical and Warm Regions (**K**). The house at the western end of the Corridor is one of the old plant-houses, and is temporarily, and until reconstruction, filled with Tropical Ferns (**L**), and opening from it is a small house for Filmy Ferns. Behind the western end of the Front Range there is a Temperate House for Palms, Tree-Ferns, and Coniferæ (**O**), and a Palm-House (**P**). Between these and the Front Range at its western end is a suite of houses (now nearing completion) which will be devoted to Monocotyledonous Plants of Tropical and Warm Regions, specially Aroids, Scitamineæ, Bromeliads, Liliaceæ, and Amaryllidaceæ; Pitcher Plants are also provided for in one of these houses (**M, N**). The central Heating Station (**Q**) for the Plant-houses lies behind the Front Range.

Adjoining the Entrance from Inverleith Row is a group of buildings including the **Office of the Garden** (**A**), the **Museum** (**B**), the **Laboratories** (**C**), and the **Lecture Hall** (**D**).

The **Museum** contains a series of exhibits illustrating the form and life-history of plants, and these are arranged so as to facilitate their use in teaching.

**Herbarium and Library.**—In the southern portion of the Garden is the Herbarium and Library (**S**). It contains a fair representation of the Floras of the world, and the herbarium of plants belonging to the University of Edinburgh is deposited here.

The **Ladies' Cloak-Room** is on the left hand of the path leading into the Garden from the Entrance from Inverleith Row (**E**).

From the higher ground of the Arboretum—at the point marked **V** on the plan—a fine panoramic view of the City of Edinburgh, flanked on the east by Arthur's Seat, and on the west by the Pentland Hills, is obtained.

## Teaching in the Garden.

Special instruction in the sciences underlying the practice of Horticulture and Forestry is provided for the Staff of the Garden. The course of instruction is spread over three years, and consists of lectures upon, and practical instruction in, the sciences taught. A Reading-room and Library is also provided for members of the Staff going through the course. Young Gardeners or Foresters desiring admission to the Staff and the course of instruction should make application to the Regius Keeper.

The Regius Keeper from time to time gives lectures which are open to the Public. The Laboratories are open to any one desirous of undertaking Botanical Research.

In recent years a School of Rural Economy has been established in Edinburgh, and a considerable part of the botanical teaching in connection with it is carried on in the Garden.

For a century and a half the offices of Regius Keeper of the Botanic Garden and Professor of Botany in the University of Edinburgh having been held by the same person, it has become the custom that the students of the University come to the Garden for instruction in Botany.

# The Life-History and Habits of Diaxenes dendrobii, Gahan, with Notes on Prevention and Remedy.

BY

R. STEWART MACDOUGALL, M.A., D.Sc.

**With Plates I. and II.**

It is safe to say that scarcely a year passes in which our country does not receive from other countries accidental additions to its insect fauna, these additions being either individuals of an already native species whose numbers are thus swelled, or perhaps quite new species. Such insects as aphides or scale-insects, which feed externally, may be introduced on nursery-stock or fruits, to which they are securely anchored by a proboscis. Apart from these, many insects pass a part or much of their life in the various stages of egg, larva, pupa, or adult, under the bark of trees, or in the wood itself, or sunk in the tissue of smaller plants; hence driftwood and imported timber and plants are fertile sources of the new insect additions above mentioned.

In my notes of the last two years, I have mention, as taken from driftwood, of living adults of such destructive forms as *Hylesinus piniperda*, *Pissodes notatus*, and *Bostrichus stenographus;* also of the living pupæ (the beetle being afterwards bred out) of *Lamia ædilis*, the Timberman, a coleopterous insect not common in our country. Again, a few months ago, in a piece of timber imported from America, I found on examination a living specimen of *Goes tigrina*, a North American longicorn beetle.

Whether such new species on issuing continue to live and gain a footing will depend on climatic and other reasons.

Our purpose at present, however, is not to discuss the possibility of the acclimatisation of such insects as live in the open, but rather to emphasise the likelihood of damage and loss consequent on the presence of new injurious species of insects introduced with such plants as orchids, which are protected under glass and kept in a temperature resembling that of their native habitat—such surroundings favouring the chance of the parasitic insect obtaining a foothold.

One such imported orchid-pest—unfortunately now only too well known in our orchid-houses—is a species of *Xyleborus* which is injurious to the genus *Dendrobium*. More than once I have had the attacked pseudo-bulbs sent to me with the insect *in situ*, in all stages of development, the last case being one of an attack on *Dendrobium eburneum* from an orchid-house at Pitlochry, Perthshire, the plants having been supplied by a dealer in the middle of England.

Another such pest (also coleopterous) is *Baridium aterrimus*, a native of the Straits Settlements. I have received it along with damaged orchids from Penang, where it is especially harmful to *Cypripedium* and *Saccolabium*. There is at least one record of the presence of Baridium in England, a specimen having been determined by Mr. Waterhouse of the British Museum. This specimen was taken at Torquay on a species of *Phalænopsis*.

A third pest whose capacity for destructive work makes it much to be feared is *Diaxenes dendrobii*, the subject of this notice. Through the courtesy of Mr. Waterhouse, I am informed that since 1894 at least eight specimens of D. dendrobii have been sent to the British Museum from different parts of England and Scotland for determination.

Late in December, 1896, I was asked to visit an orchid-house in Midlothian where a number of the plants had been ruined by some agency or other, insects being suspected. Attracted by discoloured patches on the pseudo-bulbs of some of the plants, I cut these open, and in each case found the larva of a longicorn beetle.

The larvæ were of all sizes from very tiny up to evidently

full-grown ones. Some of these last I carried away with me, and at the Royal Botanic Garden, Edinburgh, bred out the imagines (six in number), these proving to be, as suspected, *Diaxenes dendrobii*. The adult beetles issued on

| | |
|---|---|
| March 2nd, 1897. | March 15th, 1897. |
| „ 6th, „ | „ 18th, „ |
| „ 8th, „ | „ 20th, „ |

With the six beetles thus won, I proceeded to work out the details of the round of life of the pest in one of the glass-houses at the Royal Botanic Garden.

## POSITION OF DIAXENES AMONG THE COLEOPTERA.

The beetle is a longicorn belonging to the family Lamiidæ and the sub-family Apomecyninæ. The genus *Diaxenes* was founded in 1884, the type being a beetle found in a Chelsea nursery on *Dendrobium Plalænopsis;* this beetle was named *Diaxenes taylorii*, *W.* The only other species of the genus is our pest.

## DESCRIPTION OF IMAGO.

I quote in full the description given in the "Annals and Magazine of Natural History" for 1894:—

"Strongly and rather closely punctured, with the punctures partly concealed by the close pubescence, this is mostly of a fulvous-brown or drab colour, but there are darker brown areas on some of the interspaces between the whitish lines; the pronotum bears three white lines—one median and one towards each side, the two latter converging anteriorly. Each elytron has about six lines of a slightly yellowish tint, of which one lies along the outer margin; the second sets out just below the shoulder and is continued in a nearly straight direction along the side of the elytron; the third proceeds from the upper part of the shoulder and joins the second a little before the apex; the next two lines are dorsal in position, they are sub-parallel to one another in the anterior fourth of the elytron, behind which they rather abruptly converge, after again diverging slightly they converge to join one another about the beginning of the apical fourth, whence they are continued as a single line up to the outer angle of the oblique apical truncature: the sixth is a very short line passing back from the base. In addition to these six lines, an ashy-grey streak may be seen along the suture, with a

rather faint and broken white line limiting it on the outer side. The body underneath has a drab pubescence with dark brown areas. The prosternum and mesosternum and the lower part of the sides of the prothorax are almost black in colour. The legs and antennæ are covered with a nearly uniform drab-coloured pubescence, but in some examples the intermediate joints of the antennæ are more or less dark brown towards the tip. The front of the head is also, in some examples, of a dark brown or nearly black colour, but this is partly due to the rubbing away of the pubescence."

The darkening in colour is occasionally very marked. One of the females used in my experiment was after a few months quite black all along the dorsal surface. The specimen from which the above description was taken measured 16¾ mm., and this is an average size. One imago I possess measures 17 mm., but I find a number smaller—thus, 14 mm., 12 mm., and one specimen is just 10 mm., but this small size was due, I think, to the poorness of the food on which the larvæ had to subsist.

## DISTRIBUTION.

It was suspected, and indeed stated, that the natural home of *Diaxenes dendrobii* was Burmah, and during the year I had an opportunity of proving it. In the month of March, at an orchid sale in London, a number of plants of *Dendrobium nobile* were bought for the Royal Botanic Garden. These plants were imported for the sale from Burmah. When they reached the Botanic Garden, before being added to the collection, they were examined carefully, and in some of the pseudo-bulbs larvæ were got which were bred up to the pupa stage, the resulting imagines being of *Diaxenes dendrobii.*

## THE EGG.

The egg is like a very tiny sausage, rounded off towards the ends. It measures 3½ mm. in length, and is 1 mm. broad at its widest part.

There is a well-marked areolation on the thick shell, giving to the egg examined under the microscope a honeycomb-appearance. The pattern is hexagonal and pentagonal, but this becomes modified at the ends of the egg. In colour the egg showed a pale whitish-green tinge as it lay in the tissue of the pseudo-bulb.

## THE LARVA.

The larva is a legless grub, convex on both dorsal and ventral surfaces. It is jawed, and has a chitinised head. Very short antennæ may be seen on careful examination. Here and there over the body are bristles. The larva is to begin with whitish in colour, but later, and especially about the time of making its cocoon, yellowish. The stigmata along each side are well marked. It measures from 20 mm. to 22 mm.

## THE PUPA.

A general knowledge of the form of the pupa will be obtained from the figures, where it will be noted how the femur and tibia of the first two pairs of legs form a sort of knee which projects slightly above the edge of the dorsal surface. The long antennæ pass back, held at the edge of the dorsal surface by the two "knees" of the first and second pair of legs. Half-way down the body of the pupa the antennæ curl round between the second and third pair of legs and, crossing the ends of the wings, run forward on the ventral surface to the tarsi of the front pair of legs. Measurements of different pupæ gave from as small as 11 mm. up to 16mm.

## LIFE-HISTORY AND HABITS.

The beetles rest during the day, sometimes at the base of the plant, with their heads, it may be, buried in the moss of the pot in which the plant is growing; sometimes on the under surface of a leaf; but the favourite place was between two almost touching pseudo-bulbs. Now and again we got them moving on the plant in the daytime, but typically they are night-feeders. Often, after dark, on going into a glass-house with a lantern, I found them browsing on the leaves or pseudo-bulbs with extended waving antennæ.

The beetles are very sluggish, remaining in the same place for long. Even a gentle prodding failed to make them move much, but never failed in drawing from the beetles a curious scraping sound like the creaking of a saddle or the noise made in cutting a cork. The sound was produced by the beetles rubbing the

front part of the mesothorax against the hind part of the prothorax. With reference to this noise—not an unusual one among the longicorn beetles—the gardener in charge of an orchid-house where *Diaxenes* was captured informed me that, not liking to take the beetle in his hand, he had picked it off "with a small pair of tongs, on which the poor creature began squeaking."

I was much struck by their protective colouration. When resting on a withered root, or on the moss of the pot, or near a withered bulb where only the whitish-grey fibres remained, it was almost impossible for a stranger to pick out the beetle, so accurately did the colour of the beetle—especially on account of the longitudinal light lines down its back—harmonise with these surroundings.

The death-feigning instinct of the imagines was also very noticeable.

The adult beetles eat greedily and are very destructive. They feed upon and destroy :—

(1) *The Pseudo-Bulbs.* Out of these they gnaw large pieces. If the pseudo-bulb be a small one it may be entirely eaten away; specially would the beetles take the youngest growth. If the pseudo-bulbs were long and narrowish they would be gnawed at one place till the weight of the upper part would break the pseudo-bulb in two. This was the case, for example, where a species of *Phajus* with a single pseudo-bulb was used as food.

(2) *The Leaves.* These were not bitten from the edge; but the surface, either upper or lower, would be gnawed until holes appeared. If the leaves were very tough—as in the case of *Lælia anceps*—a hole might not result, but the scraped surface remained to testify to the work of the feeding beetles. Often a leaf would be bitten and gradually thinned away near its place of attachment to the pseudo-bulb, and the leaf, becoming top-heavy, bent over and broke or hung down.

(3) *The Rhizome.* Sometimes the exposed part of the rhizome would also be eaten away.

(4) *The Roots.* Several times in the course of the experiment fairly thick roots were bitten through; but a commoner damage to the root was the gnawing away of the external parts into the central cylinder (as shown in one of the figures).

The effect of all the above destruction was evidenced by the

poorness of the plant. Pseudo-bulbs that normally would have borne three flowers only produced one, and sometimes none at all. The young pseudo-bulbs, following attack on the plant, were only half the size compared with the growth made in a previous year.

The females after copulation lay their eggs in the pseudo-bulbs, often at the apex from where a leaf springs. I believe, from the amount of food a larva eats, that, unless the pseudo-bulb be a very large one, only one egg will be laid in a pseudo-bulb. I certainly found two eggs laid in the pseudo-bulb of a *Coelogyne cristata*, and also two in one pseudo-bulb of a *Coelogyne flaccida*, but this I feel sure was due to the beetles not having a sufficiently large number of plants to lay on. In both of these cases I had to remove one larva and place it in another pseudo-bulb.

The eggs hatch in less than a fortnight, and the grubs feed greedily. They bore a tunnel down the pseudo-bulb from the place of hatching, the surrounding tissue browns, and soon all down one side of the pseudo-bulb the decayed brown-blotched channel invites the attention of the observer to the destructive work of the enclosed larva. All the soft parts are then mined away, so that nothing is left of the pseudo-bulb save the outer epidermal rind and the strands of fibro-vascular bundles which run longitudinally down the hollowed-out pseudo-bulb from end to end like strands of fine string.

The larvæ wriggle about very actively if laid on the ground or held in the hand, while in their tunnels they move as easily and as readily backwards as forwards.

If the pseudo-bulb has been too small and has not afforded enough food to the larva, the latter immediately proceeds to mine through the rhizome until it reaches another sound pseudo-bulb, into which it enters. One such larva that did not find enough to satisfy it in one *Coelogyne cristata* pseudo-bulb tunnelled through 3½ cm. of rhizome and up into another, which it completely gutted. This method of leaving one pseudo-bulb and entering another was often observed during the experiment. I may add that larvæ removed from their tunnels and placed by themselves alongside a broken-off pseudo-bulb were quite able to make an entrance. On an infested plant the pseudo-bulbs may

show all stages from still healthy not yet attacked ones to others beginning to brown and to others more than half brown, up to the perfectly withered and blotched pseudo-bulb which gives to the slightest pressure.

The full-fed larva makes a cocoon by weaving together the fibres of the hollowed pseudo-bulb. The larvæ do not immediately pupate on the formation of the cocoon, but lie as larvæ on it may be for a lengthened period. One such larva, watched through a little chink cut in the cocoon, lay for twenty-three days before pupating, but others lay very much longer. In one experiment where the plant was *Odontoglossum citrosmum*, the larva had made its cocoon by December 17th, 1897, and the imago did not issue till April 24th, 1898. I did not wish to disturb this cocoon, and therefore cannot add the date of the change to the pupal condition.

Once the larva becomes a pupa, the pupal stage lasts on an average twenty-four or twenty-five days. Here is a Table showing some of the times, where the changes were watched through a chink purposely made in the cocoon:—

| Pupa. | Beetle issued. |
|---|---|
| October 11, . . . | November 4. |
| January 27, . . . | February 26. |
| February 6, . . . | March 2. |

The escaping imago bites a little round hole in the cocoon and walks out, or, if the pseudo-bulb be unbroken, through pseudo-bulb as well.

Development from egg to imago can take place in three and a half to four months, but may take much longer. Thus, in a *Coelogyne cristata* the beetles had an opportunity of egg-laying from June 10th to July 27th, and I had issue of imagos on October 11th, October 18th, and the beginning of November. If a long time be spent in the cocoon before the larva pupates the above developmental period will correspondingly be lengthenend out; the character of the food and the temperature will also each have an effect.

The following Table shows some of the results as regards variation in length of the life cycle:—

| Plant. | Time during which Beetles had opportunity to lay Eggs. | Time of Issue of New Brood. |
|---|---|---|
| *Coelogyne cristata.* | June 10—July 27, 1897. | October 11, 1897.<br>October 18, 1897.<br>Beginning of Nov. |
| *Coelogyne flaccida.* | July 27—Aug. 9, 1897. | April 7, 1898. |
| *Odontoglossum citrosmum.* | July 27—Aug. 24, 1897. | April 24, 1898.<br>May 2, 1898. |

It may be interesting to note how long my six imagines lived.

Issuing as imagines between March 2nd and March 20th, 1897—

The 1st died on April 8th, 1897.
„ 2nd „ May 28th, „
„ 3rd „ July 5th, „
„ 4th „ October 5th, „
„ 5th „ „ „ „
„ 6th „ Nov. 18th, „

Although *Diaxenes dendrobii* is called the "dendrobe-orchid beetle," I am sorry to add that it does not content itself with infesting the *Dendrobium nobile* from Burmah. I have not found any orchid with marked pseudo-bulbs refused as food. In the following orchids my six insects bred, the feeding larvæ quite ruining the plants:—

*Lælia anceps.* *Coelogyne flaccida.*
*Coelogyne cristata.* *Odontoglossum citrosmum.*

The orchid-house where I obtained my original material was quite ruined by the insect, and I took young or old larvæ from the following orchids:—

*Dendrobium Farmerii.*
„ *Griffithianum.*
„ *thyrsiflorum.*
„ *formosum.*

*Lælia anceps* (several varieties).
*Cattleya Mossiæ.*
„ *Trianæ.*

The day temperature of the orchid-house referred to was never below 60 degs. F., and the night temperature never below 55 degs. F. The temperature of the house where my experiment took place was higher than this.

Besides the species named above as plants in which my beetles bred, the following other orchids were used as food:—

| | |
|---|---|
| *Dendrobium nobile.* | *Cattleya* sp. |
| " *cariniferum.* | *Phajus* sp. |
| " *Wardianum.* | *Oncidium* sp. |

## Preventive and Remedial Measures.

Unfortunately in connection with this pest, there seems to be every possible combination against the plant and in favour of *Diaxenes dendrobii*:—

The beetle breeds in a number of genera.

Many genera can be used as food.

The beetles, owing to their colour and their being night feeders, escape notice.

The length of development from egg to imago is not excessive.

The imagines have a fairly long life.

From what I have seen of the work of this beetle, I have no hesitation in saying that *Diaxenes dendrobii* is the very worst of orchid-pests, and yet, with reasonable care, successful war can be waged against it.

1. Let all imported plants before being added to a collection be carefully gone over. Any brown discoloured pseudo-bulbs should be suspected and examined for the larva. Perfectly sound pseudo-bulbs have a firm feel to the fingers; infested pseudo-bulbs "give" a little on being pressed.
2. Owners or cultivators of orchids should keep a careful look-out for the work of the imago. Its damage is not to be mistaken for any other—how characteristic it is the figures show. Any found beetles should be destroyed. They must be searched for, however, after nightfall with a lamp or lantern.
3. That the larva has got to work may be known by a gradual discolouration down one side of the pseudo-

bulb; this will spread over the whole. The enclosed grub must be cut out, or, if the pseudo-bulb is far gone, let it be cut off bodily and the whole destroyed.

## BIBLIOGRAPHY.

Woodward, in Gardeners' Chronicle, 1883, mentions receipt of a larva taken from an orchid. It was dead and could not be identified, but I am satisfied the insect was a species of *Diaxenes.*

Gahan, C. J. Description of a new longicorn beetle of the genus *Diaxenes*, in Ann. Mag. Nat. Hist., Ser. 6, xiii (1894), p. 520.

Donge, E. Exhibited a larva and imago of the insect taken from the conservatory of a horticulturist in Paris. See Ann. Soc. Entom. France, lxiii (1894), also, Bull. Soc. Entom. France, 1895, p. vii.

Xamben, Capt. Supplies notes on larval habits and upon metamorphosis in Ann. Soc. Entom. France, lxiv (1895), also in Bull. Soc. Entom. France, 1895, p. ccxlix.

## EXPLANATION OF THE FIGURES
### in Plates I. and II.

Illustrating Dr. Stewart Macdougall's paper on *Diaxenes dendrobii*, Gahan.

Fig. 1.—Imago from life. Natural size.
„ 2.—Egg from side. Greatly magnified.
„ 3.—End view of egg-shell, showing characteristic areolation. Greatly magnified.
„ 4.—Full-grown larva. Slightly magnified.
„ 5.—Pupa removed from cocoon, ventral surface. Twice natural size.
„ 6.—Pupa removed from cocoon, dorsal surface. Twice natural size.
„ 7.—Pseudo-bulb of *Dendrobium* with larva (not full grown) that has been mining, as shown by the dark discoloured tissue. Natural size.
„ 8.—Cocoon enclosing larva, in hollowed-out pseudo-bulb of *Coelogyne cristata.* Natural size.
„ 9.—Cocoon showing escape-hole, in pseudo-bulb of *Dendrobium.* Slightly reduced.
„ 10.—Three beetles seen on plant of *Dendrobium cariniferum.* Slightly reduced.
„ 11.—Adult beetle on *Dendrobium cariniferum.* Magnified.
„ 12.—Under-surface of leaf of *Lælia anceps* gnawed by imago. Two-thirds natural size.
„ 13.—*Coelogyne cristata*, showing leaves characteristically injured by imago. Half natural size.
„ 14.—*Cattleya*, showing pseudo-bulbs and roots gnawed by imago. Natural size.

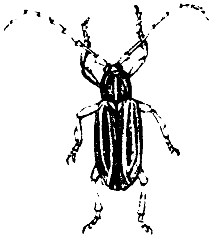

Fig 1

Fig. 4.

Fig. 2.

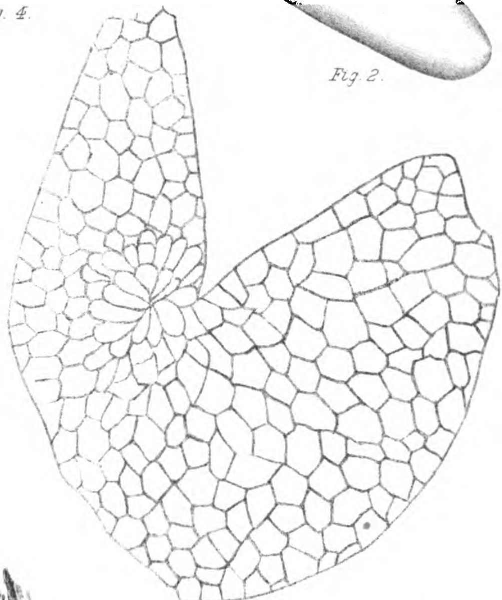

Fig. 3.

Fig 5.

Fig. 6.

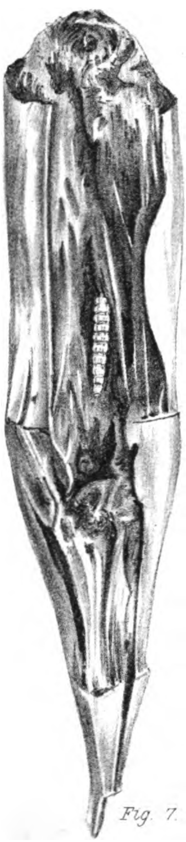

Fig. 7.

Fig. 9.

Fig. 10.

MacDougall—On *Diaxenes Dendrobii*, Gahan.

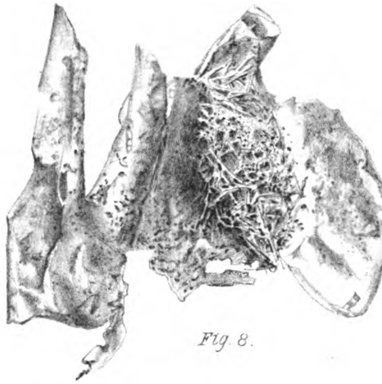

Fig. 8.

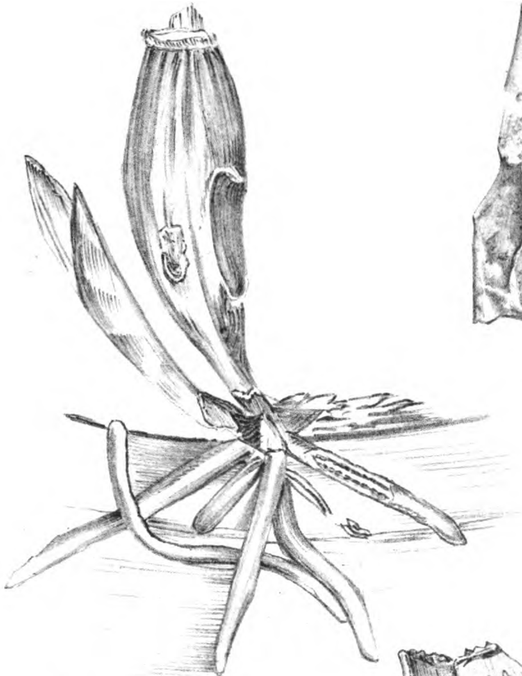

Fig. 14.

Fig. 11

Fig. 13.

Fig. 12.

MacDougall—On *Diaxenes Dendrobii*, Gahan.

# On the twisting of the leaves on their bases on the horizontal shoots of the flat-leaved Spruces (PICEA § OMORICA) as contrasted with the same phenomenon in the flat-leaved Silver Firs (ABIES), the flat-leaved Hemlock Firs (TSUGA), and the Douglas Fir (PSEUDO-TSUGA).

BY

A. D. RICHARDSON.

**With Zincographs 1—10.**

In the flat-leaved spruces, in which the stomatic leaf-surface is morphologically the upper one, and which constitute Willkomm's section *Omorica* of the genus *Picea*, the twisting of the leaves on their bases on the horizontal (plagiotropous) shoots, in order to direct their stomatic surfaces downwards, differs from that which obtains in flat-leaved silver and hemlock firs, and in the Douglas fir, in all of which the stomatic leaf-surface is morphologically the under one, in being reversed in direction, and, as a result of this reversion in direction, in the order of succession in which the leaves twist on their bases from the position in the median plane of the shoot at which no twisting takes place to that at which the maximum is reached being also reversed.

In a flat-leaved spruce, a leaf arising in the median plane upon the upper side of a horizontal shoot does not twist on its base, but bends forward and becomes nearly parallel in direction with the shoot, so that its stomatic (upper) surface is directed downwards. A leaf arising in the median plane upon the under side of a horizontal shoot, on the other hand, twists on its base through 180 degrees in order to direct its stomatic (upper)

surface downwards, and, by a swing movement at its base, which is independent of the twisting movement, it moves upwards so that it usually lies in a more or less horizontal plane; and it also moves outwards to a position nearly at a right angle to the direction of the shoot. In the leaves arising from the shoot on either side of the median plane, more or less twisting takes place at the base of each, according to its position on the axis, in order to direct its stomatic (upper) surface downwards, the amount through which each twists (assuming the direction of the shoot to be quite horizontal, and the median plane of the leaf after twisting to be truly vertical) being equal to the angular divergence of its point of insertion from that of a leaf inserted in the median plane in which no twisting takes place—in other words, the twisting commences in the leaves adjacent to those in the median plane upon the upper side of the shoot and increases as successive leaves are passed through from above downwards. By a swing movement at the base, the leaves lying on either side of the median plane move upwards or downwards, according to their positions on the axis, so that they arrange themselves in a series of superposed more or less horizontal planes lying between those of the uppermost and undermost leaves of the shoot; and they also move outwards into positions more or less divergent in direction from that of the axis, according to their positions thereon, the divergence increasing as successive leaves are passed through from above downwards from a few degrees in those adjacent to the leaves in the median plane upon the upper side of the shoot to nearly a right angle in those adjacent to the leaves in the median plane upon the under side of it.

In flat-leaved silver firs, and in the Douglas fir, on the other hand, in which the stomatic leaf-surface is morphologically the under one, a leaf arising in the median plane upon the upper side of a horizontal shoot twists on its base through 180 degrees in order to direct its stomatic (under) surface downwards, while a leaf arising in the median plane upon the under side of a horizontal shoot does not twist, but moves upwards by a swing movement at its base, so that it usually lies in a more or less horizontal plane; and it also moves outwards into a position nearly at a right angle to the direction of the shoot. As is the

case in the flat-leaved spruces, the leaves arising from the shoot on either side of the median plane twist more or less on their bases according to their positions on the axis, the amount through which each twists being equal to the angular divergence of its point of insertion from that of a leaf inserted in the median plane in which no twisting takes place; but, contrary to what takes place in the case of the spruces, the twisting here commences in the leaves adjacent to those in the median plane upon the under side of the shoot and increases as successive leaves are passed through in an upward direction. These leaves also move upwards or downwards, according to their positions on the axis, by a swing movement at the base, into more or less horizontal positions, as in the case of the leaves corresponding with them in position on the horizontal shoots of the flat-leaved spruces, and they also move outwards into positions more or less divergent in direction from that of the shoot; but this movement, unlike that which occurs in similarly situated leaves in the flat-leaved spruces, varies in different species of flat-leaved silver firs. In species such as *Abies grandis* and *A. Lowiana* all the leaves on the horizontal shoots move outwards into positions nearly at right angles to the direction of the axis, so that a "pectinate" arrangement is produced; but in other species such as *A. amabilis* and *A. Nordmanniana* the leaves on the upper sides of the horizontal shoots assume a disposition having a somewhat superficial resemblance to that of the leaves of the flat-leaved spruces, inasmuch as the uppermost leaves, in addition to twisting on their bases, often bend forward, so that they lie almost parallel in direction with the shoot, while those adjacent to them on either side move outwards into positions more or less divergent in direction from that of the axis, the divergence increasing as successive leaves are passed through in a downward direction to, in some instances, nearly a right angle in those adjacent to the leaves in the median plane upon the under side of it.[1]

[1] These species are taken as representing perhaps the two extremes of leaf-arrangement in the flat-leaved silver firs—*A. grandis*, Lindl., and *A. Lowiana*, Murray, on the one hand being very pronouncedly "pectinate," while *A. amabilis*, Forbes, and *A. Nordmanniana*, Spach, are more or less what may be termed "spruce-like." Between these extremes lie a number of species which are more or less intermediate, such as *A. pectinata*, DC., *A. balsamea*, Mill., *A. sibirica*, Ledeb., *A. Veitchii*, Lindl., and others.

In some flat-leaved hemlock firs, such as *Tsuga Sieboldii*, the arrangement of the leaves on the horizontal shoots is essentially the same as that which obtains in flat-leaved silver firs and in the Douglas fir; but in such species as *Tsuga canadensis* and *Ts. Mertensiana*, and one or two others, a slight divergence occurs. In the leaves inserted in the median plane upon the upper side of the shoot, which are generally smaller than the others, no twisting on the base takes place. These leaves behave in precisely the same way as do those in a corresponding position on the horizontal shoots of the flat-leaved spruces, but with this difference, that whereas in the spruces the stomata, being on the upper side of the leaf, become directed downwards when it bends forward in the direction of the apex of the shoot, in these hemlock firs, owing to their being on the under side of the leaf, they become directed upwards.

In the flat-leaved spruces, then, in consequence of the stomata being located on the upper leaf-surface, the arrangement of the leaves on the horizontal shoots is quite distinct from that in flat-leaved silver and hemlock firs, and in the Douglas fir. In these latter the mode of twisting of the leaves on their bases is identical with that observable in a plagiotropous shoot of such a plant as the common yew, or in fact of any broad-leaved plant such as *Diervilla* or *Philadelphus*—that is to say, the direction, as seen from above, in which the leaves twist on their bases on a horizontal shoot, when they come to occupy positions nearly at right angles to its axis, is away from the apex of the shoot, or when nearly parallel with it the direction of twisting is away from the median plane on the upper side of the shoot. In Figs. 1 and 2 horizontal shoots of this sort are represented diagrammatically as seen from above. The centre line represents the axis, the lateral lines the leaves, and the curved arrows show the direction in which the leaves twist on their bases. Fig. 1 illustrates the arrangement of the leaves on the horizontal shoots in such flat-leaved silver firs as *A. grandis* and *A. Lowiana*, and also the arrangement on the under side of the shoot in such flat-leaved species as *A. amabilis* and *A. Nordmanniana*, while Fig. 2 illustrates the arrangement on the upper side of the shoot in species such as the last named. In the case of a flat-leaved spruce, on the other hand, the direction in which the leaves

twist is, when viewed from above, either towards the apex of the shoot, as represented in Fig. 3, which illustrates the

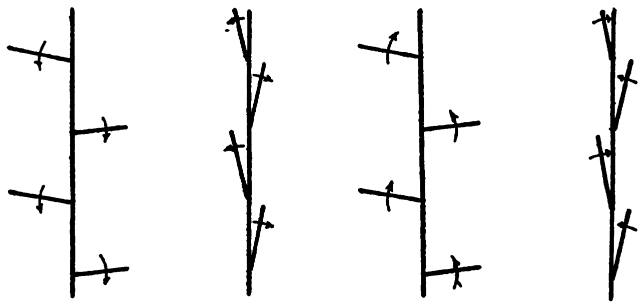

Fig. 1 Fig. 2 Fig. 3 Fig. 4

Figs. 1 and 2. Directions of twisting and movement in silver fir.
Figs. 3 and 4. Directions of twisting and movement in spruce.

arrangement of the leaves on the under side of the shoot, or towards the median plane on the upper side of the shoot, as represented in Fig. 4, which illustrates the arrangement on the upper side of the shoot.

In plagiotropous shoots in which the stomatic leaf-surface is morphologically the under one, and where the leaf-arrangement is normally not a truly distichous but a polystichous one, a pseudo-distichous arrangement is frequently brought about either by twisting and other movements of the leaves on their bases, or by torsion of the axis itself. In *Diervilla* and *Philadelphus* the leaves are opposite and decussate on the orthotropous shoots, but they all lie in one horizontal plane on the plagiotropous shoots, with their stomatic surfaces directed downwards. In these cases the pseudo-distichous arrangement on the plagiotropous shoots is brought about by torsion of the axis alternately to right and left between the nodes, so as to bring all the points of insertion of the leaves into nearly the same plane, and at the same time each leaf twists at its base through 90 degrees and brings its surface into a horizontal position, so that they all lie in the same horizontal plane. This arrangement is illustrated diagrammatically in Fig. 5, which represents a plagiotropous shoot of this sort as viewed from above.

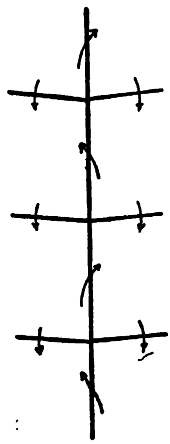

*Fig. 5*

Direction of twisting of shoot and leaves in *Diervilla*.

The curved arrows on the central axis indicate the direction in which it twists in each successive internode.

In the Irish yew all the shoots are orthotropous and the leaf-arrangement is polystichous, being in fact a $\frac{5}{13}$ spiral arrangement. In the common yew, of which the Irish yew is only a variety, most of the shoots are plagiotropous, and the leaves, although really spirally arranged, become pseudo-distichous by twisting and swing movements on their bases, but here there is no torsion of the axis as in *Diervilla* and *Philadelphus*.

In flat-leaved silver firs, and in the Douglas fir, there is a pseudo-distichous arrangement of the leaves on the horizontal shoots which, as before mentioned, is identical with that which occurs in common yew. In such species as *Abies grandis* asnd *A. Lowiana* this pseudo-distichous arrangement of the leaves is brought about independently of the twisting of the leaves on their bases by the way in which they move outwards on either side of the shoot into positions nearly at right angles to the direction of its axis. In species like *A. amabilis* and *A. Nordmanniana* the pseudo-distichous arrangement is often masked by the upper leaves assuming directions parallel with, or only slightly divergent from, that of the axis. But, as the direction in which the leaves twist on their bases on the upper side of the shoot is away from the median plane, as viewed from above, their stomatic (under) surfaces turn outwards from each other in opposite directions, to either side of the shoot, so that there is a parting or shedding of the leaves along the median plane on the upper side; and as there is also a parting or shedding of the leaves by the swing movement already referred to along the median plane on the under side of the shoot, a pseudo-distichous arrangement is the result. The resemblance between the arrangement on the upper sides of the horizontal shoots here and that of the flat-leaved spruces is therefore entirely superficial. In a flat-leaved spruce, on the other hand,

a pseudo-distichous arrangement is impossible. The leaves in the median plane upon the upper side of a horizontal shoot do not twist on their bases, nor do they move to either side of the shoot, while those adjacent to them on either side twist towards, not away from, the median plane, as viewed from above, so that there is no parting or shedding along the upper side of the shoot, and therefore no pseudo-distichous arrangement.[1]

Figures 6-10 will serve to illustrate the various points dealt with in the preceding pages, and they will also serve to show how the positions of the tissues of the leaves are affected from a morphological point of view by the twisting and other movements which take place at the leaf base, a matter in regard to which some misconception seems to exist in the descriptive accounts of some of the flat-leaved species of *Picea*.

Fig. 6 represents diagrammatically on a ground plan the positions assumed by the leaves in an erect (orthotropous) shoot of a flat-leaved silver or hemlock fir, or of the Douglas fir, while Fig. 8 represents the same thing in a flat-leaved spruce. In the figures the axis of the shoot occupies the centre, and the leaves are arranged in a circle surrounding it, the spiral arrangement being disregarded in order not to introduce complications. The number of leaves (twelve) fixed upon is purely arbitrary, the even number being adopted in order to avoid fractions of a degree. The leaves are numbered consecutively, and the angular divergence from zero (leaf 1) is indicated on the outside of each leaf. The various tissue-groups of the leaf are indicated thus:—X = xylem; P = phloem; R.C. = resin-canals; S.S. = stomatic surface.

A glance at Figs. 6 and 8 will show that they differ in one particular only—namely, the position of the stomatic surface of the leaf. In Fig. 6 it is in the normal position on the phloem-side of the leaf, but in Fig. 8 it is on the xylem-side and faces the axis of the shoot.

[1] The arrangement of the leaves on the horizontal shoots of spruces (flat-leaved and other) is frequently incorrectly described as pseudo-distichous. Dr. Engelmann, in Watson's Flora of California, II. p. 121, describes the leaves of *Picea* as "spirally arranged all round the branchlets or (by a twist of the base) somewhat 2-ranked," and other authorities variously refer to them as being "2-ranked," "2-rowed," or "pseudo-distichous."

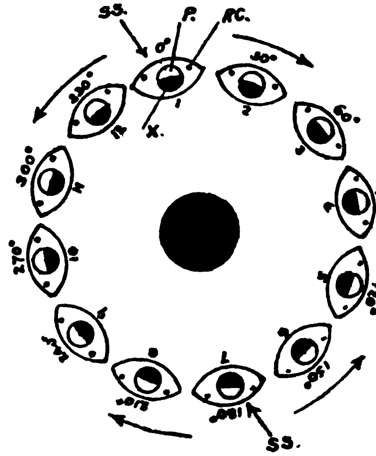

FIG. 6

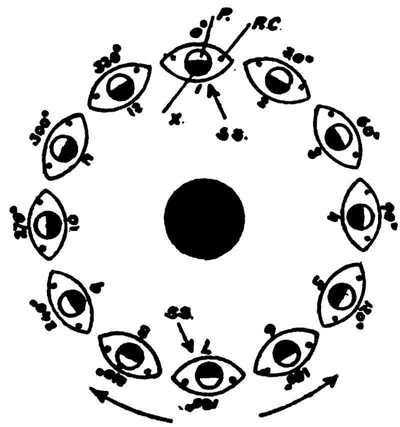

FIG. 8

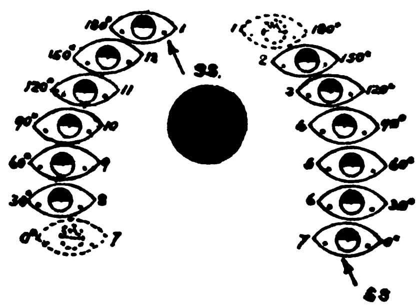

FIG. 7

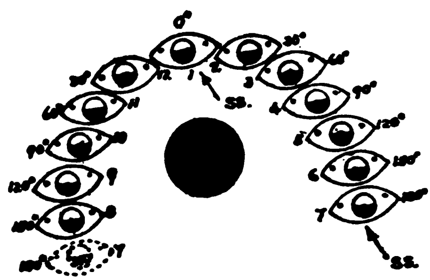

FIG. 9

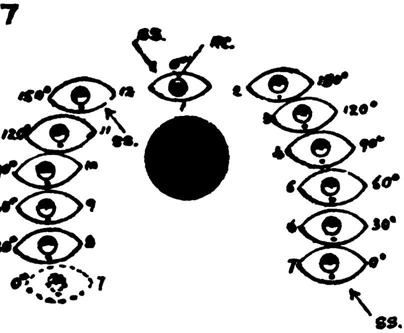

FIG. 10

Figs. 6 and 7. Arrangements in flat-leaved silver fir, *Tsuga Sieboldi*, and Douglas fir.
Figs. 8 and 9. Arrangements in flat-leaved spruce.
Fig. 10. Arrangement in *Tsuga canadensis*, *Ts. Mertensiana*, and others.

Fig. 7 represents the positions assumed by the leaves in flat-leaved silver firs, in some hemlock firs, and in the Douglas fir when such a shoot as that represented in Fig. 6 becomes horizontal. The leaves corresponding to those in Fig. 6 are indicated by corresponding numbers, and the degree-numbers indicate the angles through which the leaves twist on their bases, as well as their angular divergences from the leaf in which no twisting takes place.

In Fig. 7, leaf 7, which is in the median plane upon the under side of the shoot, is the one in which no twisting takes place, but, by the swing movement on its base already referred to, it moves upwards and outwards to the position indicated in the figure. As, however, its point of insertion is in the median plane of the axis, it may move either to the right or to the left. In leaf 1, which is in the median plane upon the upper side of the shoot, on the other hand, the maximum amount of twisting at the base takes place, and owing to its being in the median plane of the shoot, it may, like leaf 7, move either to the right or to the left. In those lying between 1 and 7, on either side of the median plane of the shoot, the amount of twisting which each undergoes is equal to the angular divergence of its point of insertion from that in which no twisting takes place, as indicated in the figure. For example, the points of insertion of leaves 4 and 10 are each divergent 90 degrees from that of leaf 1, and this is equal to the angle through which each twists in order to bring its median plane into a vertical position.

The curved arrows above and beneath Fig. 6 indicate the direction in which the leaves shed away from the median plane of the axis, on the upper side by twisting, and on the under side by a swing movement at the base, when a shoot such as this becomes horizontal as in Fig. 7.

Figure 9 represents the positions assumed by the leaves in a flat-leaved spruce when a shoot such as that represented in Fig. 8 becomes horizontal, and the leaf-numbers and degree-numbers have the same significance as those in Fig. 7. Leaf 1 in Fig. 9 is that in which no twisting takes place, and it retains precisely the same position in relation to the axis as does the corresponding leaf in Fig. 8. In leaf 7, on the other hand, the maximum amount of twisting on the base takes place, and in addition

to this twisting there is the swing movement at the base, by which the leaf moves upwards and outwards into the position indicated in the figure; and, as the point of insertion of this leaf is in the median plane upon the under side of the shoot, it may move either to the right or to the left. In the leaves lying between 1 and 7, on either side of the median plane of the shoot, the same rule as to twisting obtains as that which governs the twisting in Fig. 7, but here the order of succession in which the leaves twist is reversed in direction as compared with that illustrated in Fig. 7.

The curved arrows beneath Fig. 8 indicate the direction in which the leaves shed away from the median plane of the axis when a shoot such as this becomes horizontal as in Fig. 9; but the shedding of the leaves along the median plane on the under side of the shoot is not here due to a swing movement at the base only, as in Fig. 7, but to a combination of both a twisting and a swing movement. Both these movements, in fact, culminate in the leaves in the median plane on the under side of the shoot in a flat-leaved spruce; whereas in a flat-leaved silver, in some hemlock firs, or in the Douglas fir, the twisting movement culminates in the leaves in the median plane on the upper side of the shoot, while the swing movement culminates in those in the median plane on the under side.

Fig. 10 represents, in the same way as in Figs. 7 and 9, the positions assumed by the leaves on a horizontal shoot of a hemlock fir such as *Tsuga canadensis*, or *T. Mertensiana*, as described on p. 16. The leaves inserted in the median plane upon the upper side of the shoot show no twisting at the base, but, bending forward in the direction of the apex of the shoot, they occupy positions similar to that of leaf 1 in Fig. 10, in which the stomatic (under) surface is directed upwards, whereas in all the other leaves of the shoot it is directed downwards as in the flat-leaved silver firs, and in the Douglas fir.[1]

[1] In a paper entitled a "Review of some Points in the Comparative Morphology, Anatomy, and Life-History of the Coniferæ," published in the "Journal of the Linnean Society, Botany, Vol. xxvii, Dr. Masters refers to the leaf-arrangement in these plants as follows (p. 247):—"Another instance of variation in the arrangement of "leaves is often seen in *Abies Nordmanniana*, *A. Pichta*, *A. amabilis*, as also in "*Tsuga canadensis*, &c. The leaves on the lateral and more or less horizontally "spreading branches, though polystichous, in reality arrange themselves in three rows,

The effect of this twisting of the leaves on their bases on the horizontal shoots of the firs and spruces referred to results in but a slight deviation from the normal condition of the internal leaf-structure, and this only in the flat-leaved spruces. In the flat-leaved silver and hemlock firs, and in the Douglas fir, there is no departure from the normal condition, and the arrangement of the internal tissues of the leaf is precisely the same both in leaves of the leader shoots (where no twisting takes place) and in leaves of the horizontal shoots; but in the flat-leaved spruces, owing to the stomata being located on the morphologically upper leaf-surface, and to the consequent inversion of the leaves on the horizontal shoots as compared with those on the leader (erect) shoots, or with those on both the erect and horizontal shoots of a flat-leaved silver fir, or the Douglas fir, the positions of the various leaf-tissues are completely reversed, so that the phloem is towards the non-stomatic, actually upper (but really morphologically under) side, and the xylem towards the stomatic under (but really morphologically upper) side, while the resin-canals occupy their normal positions on the phloem side of the leaf. The only anatomical change which results from this abnormal (inverted) position of the leaves on the horizontal shoots of these flat-leaved spruces is the formation of palisade cells in the non-stomatic upper (but really morphologically under) side of the leaf in two or three of the species; and no doubt it is the abnormal position of these cells on the same side of the leaf as the resin-canals (which always belong to the under side of the leaf[1]) that has led to the little

"one on either side of the branch (in which case the leaves are nearly at a right "angle to the branch), and one in the median plane of the upper surface (in which "case the leaves are appressed along the branch parallel to its main axis). The "median leaves are usually smaller than the lateral ones."

It is quite true, as Dr. Masters says, that in hemlock firs like *Tsuga canadensis* the leaves are really arranged in three groups, but such a description is incorrect when applied to any of the flat-leaved silver firs, as has been shown in this paper.

[1] In connection with this it may be pointed out here that the figures of the transverse sections of the leaves of *Picea Alcockiana* and *P. Glehnii* of the "Gardeners' Chronicle" (Vol. xiii, N.S., pp. 212 and 301) and of the "Journal of the Linnean Society" (Botany, Vol. xviii, pp. 509 and 513) are, judging from the positions of these resin-canals, evidently inverted, as is also apparently that of *P. Breweriana* of the "Gardeners' Chronicle" (Vol. xxv, N.S., p. 497). In the two first-mentioned species no twisting takes place at the bases of the leaves on the horizontal shoots, so

confusion which exists in the descriptive accounts of some of these species.

In conclusion, it may be pointed out that in the silver firs (*Abies*) and in the hemlock firs (*Tsuga*) species occur in which the leaves are not distinctly flattened, and where, as in the true spruces (*Picea* § *Eupicea*), the stomata are more or less evenly distributed over the four faces of the leaf. This occurs in such species as *Abies Pinsapo*, *A. nobilis*, *A. magnifica*, and others, amongst silver firs, and in *Tsuga Hookeriana* of gardens amongst hemlock firs. In such cases there is, of course, as in the case of spruces, no pseudo-distichous arrangement.

that the resin-canals are always in the actually, as well as the morphologically, under part of the leaf. About *P. Breweriana*, a species of which I have not seen specimens, I am unable to express an opinion as to whether the leaves twist on the horizontal shoots or not. Beissner ("Handbuch der Nadelholzkunde," p. 350) places it amongst the true spruces (*Eupicea* of Willkomm), in which no twisting of the leaf base occurs; but Professor Sargent says ("Silva of North America," Vol. xii, p. 52) "it most resembles in leaf structure and in the form of its cone-scales the flat-leaved *P. Omorica* of the Balkan Peninsula." Judging from the figures alone (both of the "Gardeners' Chronicle" and of the "Silva") it would appear that the stomata are confined to one leaf-surface only, and, from the position in which the canals are shown, no doubt this is the upper one, as in the other flat-leaved species. I therefore incline to Professor Sargent's opinion that it is more closely allied to the flat-leaved species than to the true spruces.

OFFICIAL COPY. Number II.

# NOTES

FROM THE

# ROYAL BOTANIC GARDEN, EDINBURGH.

NOVEMBER 1900.

CONTENTS.




GLASGOW:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE
BY JAMES HEDDERWICK & SONS,
AT THE "CITIZEN" PRESS, ST. VINCENT PLACE.

SOLD AT THE GARDEN,
And to be purchased, either directly or through any Bookseller, from
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# List of Seeds Collected in the Royal Botanic Garden, Edinburgh, during the Year 1900.

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The following is a list of plants cultivated in the Royal Botanic Garden, Edinburgh, from which ripened seeds have been collected during the year 1900. The quantity of seed obtained from some of the species is of limited amount. The seeds are available for exchange, but they are not for sale :—

## HERBACEOUS PLANTS.

**Acantholimon**
~~glumaceum, *Boiss.*~~

**Achillea**
Jaborneggi ×, *Halacsy.*

**Aciphylla**
squarrosa, *Forst.*

**Aconitum**
Anthora, *Linn.*

**Actæa**
alba, *Mill.*
spicata, *Linn.*

**Adenophora**
stylosa, *Fisch.*

**Æthionema**
cappadocicum, *Spreng.*
~~cordatum, *Boiss.*~~

**Agrimonia**
Eupatoria, *Linn.*

**Alonsoa**
caulialata, *Ruiz* et *Pav.*

**Alstrœmeria**
chilensis, *Lem.*

**Alyssum**
calycinum, *Linn.*
creticum, *Linn.*
libycum, *Coss.*
Moehlendorfianum, *Hort.*
montanum, *Linn.*
saxatile, *Linn.*

**Androsace**
elongata, *Linn.*, var. nana.
~~filiformis, *Retz.*~~
lactea, *Linn.*
maxima, *Linn.*

[Notes, R.B.G., Edin., No. II., 1900.]

**Anemone**
alpina, *Linn.*
— var. sulphurea.
Halleri, *All.*
obtusiloba, *D. Don.*
polyanthes, *D. Don.*
pratensis, *Linn.*
rivularis, *Buch.-Ham.*
sulphurea, *Linn.*
sylvestris, *Linn.*

**Anthericum**
Liliago, *Linn.*
— var. algeriense.

**Aquilegia**
Bertolonii, *Schott.*
formosa, *Fisch.*

**Arabis**
albida, *Stev.*
Allionii, *DC.*
alpina, *Linn.*
— var. anachoretica, *Port.*
blepharophylla, *Hook.* et *Arn.*
Breweri, *S. Wats.*
lucida, *Linn. fil.*

**Arenaria**
austriaca, *Jacq.*

**Arum**
maculatum, *Linn.*
palæstinum, *Boiss.*

**Asarum**
canadense, *Linn.*
caudatum, *Lindl.*
europæum, *Linn.*
grandiflorum, *Klotzsch.*

**Aster**
alpinus, *Linn.*
— var. altaicus.
— var. ruber.

**Astilbe**
chinensis, *Franch.* et *Sav.*
Thunbergii, *Miq.*

**Astragalus**
danicus, *Retz.*
Glyciphyllus, *Linn.*

**Astrantia**
carniolica, *Wulf.*
major, *Linn.*

**Athamanta**
Matthioli, *Wulf.*

**Aubrietia**
deltoidea, *DC.*, var. Columnæ (*Guss.*).

**Avena**
sterilis, *Linn.*

**Barbarea**
arcuata, *Reichb.*
præcox, *R. Br.*
vulgaris, *R. Br.*

**Bottionea**
thysanthoides, *Colla.*

**Brassica**
Cheiranthos, *Vill.*

**Bryonia**
dioica, *Jacq.*

**Bulbinella**
Hookeri, *Benth.* et *Hook. fil.*

**Calochortus**
venustus, *Benth.* var. citrinus.
— var. Eldorado.
— var. oculatus.
— var. pictus.

**Camelina**
sativa, *Crantz.*
sylvestris, *Wallr.*

**Campanula**
barbata, *Linn.*
glomerata, *Linn.*
Hendersoni, *Hort.*
lactiflora, *Bieb.*
latifolia, *Linn.*, var. macrantha (*Fisch.*)
linifolia, *Scop.*
persicifolia, *Linn.*
— var. alba.
— var. Backhousei.
— var. grandiflora.
rapunculoides, *Linn.*
rotundifolia, *Linn.*
— var. alba.
Trachelium, *Linn.*, var. aggregata.
— var. flore pleno.

**Cardamine**
~~bulbifera, *R. Br.*~~

**Carlina**
corymbosa, *Linn.*

**Cerastium**
perfoliatum, *Linn.*

**Chærophyllum**
aromaticum, *Linn.*

**Cheiranthus**
Cheiri, *Linn.*

**Chelidonium**
majus, *Linn.*
— var. laciniatum (*Mill.*).

**Chrysanthemum**
anserinæfolium, *Hausskn.* et *Born.*
ceratophylloides, *All.*
maximum, *Ramond.*

**Cochlearia**
officinalis, *Linn.*

**Codonopsis**
rotundifolia, *Royle.*

**Collomia**
grandiflora, *Dougl.*

**Coronilla**
elegans, *Panč.*

**Corydalis**
glauca, *Pursh.*

**Delphinium**
crassicaule, *Ledeb.*
elatum, *Linn.*, var. glabra.
grandiflorum, *Linn.*
hybridum, *Steph.*
speciosum, *Bieb.*, var. turkestanicum.
truncatum, *Hort.*
velutinum, *Bertol.*

**Dianthus**
cæsius, *Sm.*
calocephalus, *Boiss.*
chinensis, *Linn.*
deltoides, *Linn.*
glacialis, *Haenke.*, var. gelidus.
Hellwigii ×, *Borb.*
mœsiacus, *Vis.* et *Panč.*
superbus, *Linn.*

**Dictamnus**
albus, *Linn.*

**Digitalis**
ambigua, *Murr.*
lutea, *Linn.*
purpurea, *Linn.*

**Draba**
arabisans, *Michx.*
aurea, *Vahl.*
carinthiaca, *Hoppe*, var. Traunsteineri (*Hoppe*).
fladnizensis, *Wulf.*
hispida, *Willd.*
incana, *Linn.*
—var. hebecarpa.
Kotschyi, *Stur.*
lactea, *Adams.*
~~longirostra,~~ *Schott*, *Nym.* et *Kotschy.*
rupestris, *R. Br.*
siliquosa, *Bieb.*

**Epilobium**
angustifolium, *Linn.*
Hectori, *Hausskn.*
luteum, *Pursh.*
parviflorum, *Schreb.*
rosmarinifolium, *Haenke.*

**Erigeron**
glabellus, *Nutt.*
macranthus, *Nutt.*
multiradiatus, *Benth.* et *Hook. fil.*
Roylei, *DC.*
speciosus, *DC.*

**Erinus**
alpinus, *Linn.*

**Erodium**
curvifolium, *Boiss.* et *Reut.*
ciconium, *Willd.*

**Eryngium**
cæruleum, *Bieb.*

**Erysimum**
thyrsoideum, *Boiss.*

**Eschscholzia**
californica, *Cham.*
—var. alba.

**Eupatorium**
cannabinum, *Linn.*

**Fritillaria**
aurea, *Schott.*
camtschatcensis, *Ker-Gawl*

**Funkia**
Sieboldiana, *Hook.*

**Gaillardia**
aristata, *Pursh.*, var. grandiflora, *Hort.*

**Gentiana**
asclepiadea, *Linn.*
punctata, *Linn.*
Saponaria, *Linn.*
verna, *Linn.*

**Geranium**
asphodeloides, *Burm. fil.*
cinereum, *Cav.*
Endressi, *Gay.*
sanguineum, *Linn.*
—var. lancastriense (*Mill.*).
—var. roseum.
sibiricum, *Linn.*
subcaulescens, *L'Herit.*

**Gerbera**
nivea, *Sch. Bip.*

**Geum**
montanum, *Linn.*
nutans, *Hort. Par.*
parviflorum, *Commers.*
pyrenaicum, *Mill.*
rubellum, *Fisch.* et *Mey*

**Globularia**
trichosantha, *Fisch.* et *Mey.*

**Gypsophila**
acutifolia, *Fisch.*
dubia, *Willd.*

**Helleborus**
antiquorum, *A. Br.*, var. roseus.
colchicus, *Regel.*

**Hesperis**
matronalis, *Linn.*

**Heuchera**
bracteata, *Ser.*
Drummondii, *Hort.*
macrophylla, *Lodd.*
sanguinea, *Engelm.*

**Hieracium**
argenteum, *Fries.*
iricum, *Fries.*
rigidum, *Hartm.*
scoticum, *Hort.*
tridentatum, *Fries.*
villosum, *Jacq.*

**Homogyne**
alpina, *Cass.*

**Hyacinthus**
romanus, *Linn.*

**Hypericum**
pulchrum, *Linn.*
Richeri, *Vill.*, var. Burseri (*Spach*).

**Iberis**
intermedia, *Guersent.*
semperflorens, *Linn.*
sempervirens, *Linn.*
—var. superba.
umbellata, *Linn.*

**Impatiens**
Noli-tangere, *Linn.*

**Incarvillea**
Delavayi, *Bureau* et *Franch.*

**Inula**
ensifolia, *Linn.*
Helenium, *Linn.*

**Iris**
sibirica, *Linn.*
—var. alba.
—var. flexuosa.
tenax, *Dougl.*

**Isatis**
tinctoria, *Linn.*

**Jasione**
montana, *Linn.*

**Kniphofia**
Tuckii, *Baker.*

**Lactuca**
muralis, *E. Mey.*

**Lathyrus**
canescens, *Gren.* et *Godr.*
macrorrhizus, *Wimm.*
magellanicus, *Lam.*
montanus, *Bernh.*

**Leontopodium**
alpinum, *Cass.*

**Lepidium**
Menziesii, *DC.*

**Leucojum**
vernum, *Linn.*, var. carpaticum (*Herb.*).

**Ligusticum**
scoticum, *Linn.*

**Lilium**
Washingtonianum, *Kellogg*, var. purpureum.

**Linaria**
maroccana, *Hook. fil.*

**Lindelofia**
spectabilis, *Lehm.*

**Linum**
alpinum, *Linn.*
perenne, *Linn.*

**Lotus**
corniculatus, *Linn.*

**Lunaria**
annua, *Linn.*

**Lupinus**
micranthus, *Dougl.*
rivularis, *Dougl.*

**Lychnis**
divaricata, *Reichb.*
Flos-jovis, *Desr.*
Githago, *Scop.*
pyrenaica, *Berger.*
Viscaria, *Linn.*
— var. splendens.

**Malva**
Alcea, *Linn.*
borealis, *Wallm.*
crispa, *Linn.*

**Mandragora**
officinarum, *Linn.*

**Meconopsis**
cambrica, *Vig.*
Wallichii, *Hook.*
— var. fusco-purpurea.

**Medicago**
truncatula, *Gaertn.*

**Melilotus**
elegans, *Salzm.*

**Mesembryanthemum**
pomeridianum, *Linn.*

**Mitella**
pentandra, *Hook.*

**Morina**
longifolia, *Wall.*

**Muscari**
Argæi, *Hort.*
armeniacum, *Leichtlin.*
botryoides, *Mill.*
Maweanum, *Baker.*
moschatum, *Willd.*

**Ochthodium**
ægypticum, *DC.*

**Œnothera**
biennis, *Linn.*

**Onobrychis**
sativa, *Lam.*

**Ononis**
arvensis, *Linn.*

**Orchis**
mascula, *Linn.*

**Oxytropis**
glabra, *DC.*
lapponica, *Gaud.*
strobilacea, *Bunge.*

**Papaver**
alpinum, *Linn.*
Heldreichii, *Boiss.*
nudicaule, *Linn.*, var. miniatum.
pilosum, *Sibth.* et *Sm.*
somniferum, *Linn.*

**Paradisea**
Liliastrum, *Bertol.*

**Pedicularis**
palustris, *Linn.*
— var. alba.

**Pentstemon**
confertus, *Dougl.*
deustus, *Dougl.*
diffusus, *Dougl.*
glaucus, *R. Grah.*, var. stenopetalus.
ovatus, *Dougl.*

**Phlomis**
setigera, *Falc.*

**Phyteuma**
orbiculare, *Linn.*
Scheuchzeri, *All.*
Sieberi, *Spreng.*
spicatum, *Linn.*

**Picrorhiza**
~~Kurroa, *Royle*~~

**Pisum**
sativum, *Linn.*

**Plantago**
Raoulii, *Decne.*

**Platycodon**
grandiflorum, *A. DC.*, var. Mariesii.

**Podopyllum**
Emodi, *Wall.*

**Polemonium**
cæruleum, *Linn.*
— var. album.
— var. monstrosum.
himalayanum, *Baker.*

**Polygonum**
viviparum, *Linn.*

**Potentilla**
alchemilloides, *Lapeyr.*
alpestris, *Hall. fil.*
malacophylla, *Borb.*
Menziesii ×, *Paxt.*
Sibbaldia, *Hall. fil.*

**Poterium**
canadense, *A. Gray.*
muricatum, *Spach.*
officinale, *A. Gray.*

**Primula**
Auricula, *Linn.*, var. monacensis.
~~calycina, *Duby*~~
capitata, *Hook.*
carniolica, *Jacq.*
elatior, *Hill*, var. carpatica (*Fuss.*).
farinosa, *Linn.*
frondosa, *Janka.*
~~involucrata, *Wall.*, var. Munroi.~~
sikkimensis, *Hook.*
~~viscosa, *Vill.*, var. decora, *Sims.*~~
— var. nivalis, *Hort.*

**Prunella**
grandiflora, *Jacq.*
vulgaris, *Linn.*
— var. alba.

**Pyrola**
media, *Sw.*
rotundifolia, *Linn.*

**Ramondia**
pyrenaica, *Rich.*
serbica, *Panč.*
— var. Nathaliæ (*Panč.* et *Petrov.*)

**Ranunculus**
acris, *Linn.*
bulbosus, *Linn.*, var. fasciatus.
Chius, *DC.*

**Reseda**
complicata, *Bory.*
Luteola, *Linn.*

**Rheum**
Rhaponticum, *Linn.*

**Sanicula**
europæa, *Linn.*

**Saxifraga**
Aizoon, *Linn.*, var. balcana, *Hort.*
— carinthiaca (*Schott*).
— Malyi (*Schott*, *Nym.* et *Kotschy*).
— minima.
— notata (*Schott*, *Nym.* et *Kotschy*).
— pectinata (*Schott*).
— punctata.
— rosularis, *Schl.*
— Sturmiana (*Schott*, *Nym.* et *Kotschy*).
aspera, *Linn.*
bronchialis, *Linn.*
— var. cherlerioides (*D. Don*).
Bucklandi, *Hort.*, var. major.
Burseriana, *Linn.*, var. multiflora.
crustata, *Vest*, var. hybrida.
decipiens, *Ehrh.*
— var. palmata (*Panč.*).
exarata, *Vill.*
granulata, *Linn.*
Hostii, *Tausch.*
— var. altissima (*Kern.*).
— var. elatior (*Mert.* et *Koch*).
hypnoides, *Linn.*
intacta, *Willd.*
— var. farinosa.
leucanthemifolia, *Michx.*
lingulata, *Bell*, var. australis (*Moric.*).
longifolia, *Lapeyr.*
mutata, *Linn.*
oppositifolia, *Linn.*
~~— var. alba.~~
paradoxa, *Sternb.*
pedatifida, *Ehrh.*
Portæ ×, *Engl.*
pseudo-sancta, *Janka.*
retusa, *Gouan*, var. bryoides.
— maritima.
rotundifolia, *Linn.*
sancta, *Griseb.*
stellaris, *Linn.*
tenella, *Wulf.*
tyrolensis, *Kern.*
umbrosa, *Linn.*, var. Ogilveana *Hort.*
— var. serratifolia (*Mackay*).

**Scabiosa**
caucasica, *Bieb.*
— var. alba.

**Scilla**
bifolia, *Linn.*, var. præcox.
festalis, *Salisb.*
— var. alba.
hispanica, *Mill.*, var. grandiflora.
patula, *DC.*
— var. major.

**Scrophularia**
nodosa, *Linn.*

**Scutellaria**
alpina, *Linn.*

**Sedum**
album, *Linn.*
Anacampseros, *Linn.*
asiaticum, *Spreng.*
stoloniferum, *S. T. Gmel.*

**Sempervivum**
arvernense, *Lecoq* et *Lamotte.*
glaucum, *Tenore.*
Pomellii, *Lamotte.*
Schottii, *Baker*, var. acuminatum (*Schott*).

**Sidalcea**
candida, *A. Gray.*
malvæflora, *A. Gray.*

**Silene**
alpestris, *Jacq.*
Armeria, *Linn.*
caucasica, *Boiss.*
colorata, *Poir.*
Cucubalus, *Wibel.*
Drummondii, *Hook.*
italica, *Pers.*
muscipula, *Linn.*
nicæënsis, *All.*
quadridentata, *Pers.*
~~rhynchocarpa~~, *Boiss.*
Saxifraga, *Linn.*
Schafta, *Gmel.*
Sendtneri, *Boiss.*
Thorei, *Duf.*
vallesia, *Linn.*
verecunda, *S. Wats.*

**Silphium**
terebinthinaceum, *Jacq.*

**Sisymbrium**
Thalianum, *J. Gay.*

**Sisyrinchium**
angustifolium, *Mill.*

**Smilacina**
racemosa, *Desf.*

**Sobolewskya**
clavata, *Fenzl*, var. cilicica.

**Solanum**
Dulcamara, *Linn.*, var. alba.

**Solidago**
elongata, *Nutt.*
multiradiata, *Ait.*, var. scopulorum.
Virgaurea, *Linn.*

**Spergula**
arvensis, *Linn.*

**Spiræa**
astilboides, *Carr.*
Filipendula, *Linn.*
Ulmaria, *Linn.*

**Synthyris**
reniformis, *Benth.*

**Thalictrum**
angustifolium, *Linn.*
calabricum, *Spreng.*

**Thalictrum**—*continued.*
glaucum, *Desf.*
minus, *Linn.*
simplex, *Linn.*

**Thermopsis**
fabacea, *DC.*
montana, *Nutt.*

**Thlaspi**
arvense, *Linn.*

**Tofieldia**
calyculata, *Wahlenb.*

**Trifolium**
agrarium, *Linn.*
alpinum, *Linn.*
pannonicum, *Jacq.*
striatum, *Linn.*

**Trillium**
erythrocarpum, *Curt.*
grandiflorum, *Salisb.*
ovatum, *Pursh.*
stylosum, *Nutt.*

**Tritonia**
rosea, *Klatt.*

**Trollius**
altaicus, *C. A. Mey.*
asiaticus, *Linn.*, var. giganteus.
europæus, *Linn.*
— var. pumilus albus.
patulus, *Salisb.*, var. albus.

**Tunica**
stricta, *Fisch.* et *Mey.*
velutina, *Fisch.* et *Mey.*

**Typha**
angustifolia, *Linn.*
latifolia, *Linn.*

**Veronica**
fruticulosa, *Linn.*
Guthriana ×, *Hort.*
longifolia, *Linn.*
~~Lyallii, *Hook.*~~ *fil.*
~~satureioides~~, *Vis.*
saxatilis, *Scop.*

**Vicia**
Cracca, *Linn.*
sylvatica, *Linn.*
unijuga, *A. Braun.*
villosa, *Roth.*

**Viola**
canadensis, *Linn.*, var. alba.
cornuta, *Linn.*
macedonica, *Boiss.* et *Heldr.*
odorata, *Linn.*, var. lutea.
persicifolia, *Roth.*
polychroma, *Kern.*
primulæfolia, *Linn.*
sylvestris, *Lam.*

**Waldsteinia**
trifolia, *Koch.*

**Wulfenia**
carinthiaca, *Jacq.*

## TREES AND SHRUBS.

**Acer**
Pseudo-platanus, *Linn.*

**Alnus**
cordifolia, *Ten.*
glutinosa, *Medic.*
incana, *Medic.*

**Amelanchier**
canadensis, *Torr. et Gray.*

**Arctostaphylos**
Uva-ursi, *Spreng.*

**Berberis**
angulosa, *Wall.*
Aquifolium, *Pursh.*

**Betula**
alba, *Linn.*
— var. pendula, *Hort.*

**Caragana**
arborescens, *Lam.*

**Clematis**
Vitalba, *Linn.*

**Colutea**
istria, *Mill.*

**Cornus**
alba, *Linn.*

**Cotoneaster**
frigida, *Wall.*
horizontalis, *Decne*
microphylla, *Wall.*
Simonsii, *Baker.*

**Cratægus**
mollis, *Scheele.*
Oxyacantha, *Linn.*
— var. pendula, *Lodd.*

**Cytisus**
nigricans, *Linn.*
scoparius, *Link.*
— var. Andreanus.

**Daphne**
Mezereum, *Linn.*
— var. album.

**Dryas**
octopetala, *Linn.*

**Genista**
sagittalis, *Linn.*

**Helianthemum**
ægyptiacum, *Mill.*
ledifolium, *Mill.*
umbellatum, *Mill.*
vulgare, *Gaertn.*
— var. mutabile.
— var. roseum.
— var. venustum.

**Ilex**
Aquifolium, *Linn.*
— var. aurea angustifolia.
— var. camelliæfolia.
— var. flavescens.
— var. fructu luteo.
— var. Hodginsii.
—var. maderensis.

**Laburnum**
alpinum, *J. S. Presl.*
vulgare, *J. S. Presl.*

**Ledum**
latifolium, *Ait.*
palustre, *Linn.*

**Nuttallia**
cerasiformis, *Torr. et Gray.*

**Olearia**
Haastii, *Hook. fil.*

**Pernettya**
mucronata, *Gaudich.*

**Prunus**
Avium, *Linn.*

**Pyrus**
Aria, *Linn.*
Aucuparia, *Gaertn.*
nivalis, *Jacq.*
rotundifolia, *Bechst.*

**Quercus**
Cerris, *Linn.*
pedunculata, *Ehrh.*
sessiliflora, *Salisb.*

**Rhamnus**
catharticus, *Linn.*
Frangula, *Linn.*

**Rhododendron**
catawbiense, *Michx.*
caucasicum, *Pall.*
ferrugineum, *Linn.*
— var. album, *Sweet.*
flavum, *G. Don.*
hirsutum, *Linn.*

**Rhododendron**—*continued.*
hirsutum, var. album.
— var. variegatum.
ponticum, *Linn.*

**Rhodotypos**
kerrioides, *Sieb. et Zucc.*

**Rosa**
rugosa, *Thunb.*
— var. alba.

**Sambucus**
canadensis, *Linn.*
nigra, *Linn.*
— var. fructu albo.

**Skimmia**
Fortunei, *Mast.*

**Symphoricarpus**
racemosus, *Michx.*

**Taxus**
**baccata,** *Linn.*
— var. Dovastoni, *Carr.*
— var. fastigiata, *Loud.*

**Thymus**
Chamædrys, *Fries*, var. comosus (*Heuff.*).

**Tilia**
vulgaris, *Hayne.*

**Veronica**
~~anomala~~, *Armstr.*
~~Bidwillii~~, *Hook. fil.*
Colensoi, *Hook. fil.*, var. glauca.
monticola, *Armstr.*
pinguifolia, *Hook. fil.*
vernicosa, *Hook. fil.*, var. purpurea.

**Viburnum**
Lantana, *Linn.*
Opulus, *Linn.*

## PLANTS UNDER GLASS.

**Acokanthera**
spectabile, *Hook. fil.*

**Actinostemma**
biglandulosum, *Hemsl.*

**Ardisia**
crenata, *Roxb.*

**Aristolochia**
brasiliensis, *Mart.*
fimbriata, *Cham.*

**Asparagus**
scandens, *Thunb.*

**Begonia**
coccinea, *Hook.*
Dregei, *Otto et Dietr.*
Knowsleyana, *Hort.*
manicata, *Cels.*
nitida, *Dry.*
Verschaffeltii, *Hort.*

**Billardiera**
longiflora, *Labill.*

**Billbergia**
pallidiflora, *Liebm.*

**Bomarea**
multiflora, *Mirb.*

**Brachychilum**
Horsfieldii, *Baker.*

**Brodiæa**
lactea, *S. Wats.*

**Camellia**
theifera, *Griff.*

**Cassia**
corymbosa, *Lam.*

**Chlorophytum**
orchidastrum, *Lindl*

**Clethra**
arborea, *Ait.*

**Cobæa**
scandens, *Cav.*

**Coffea**
arabica, *Linn.*

**Costus**
igneus, *N. E. Br.*

**Cotyledon**
Desmetiana, *Hemsl.*

**Crossandra**
undulæfolia, *Salisb.*

**Cyclanthera**
explodens, *Naud.*

**Darlingtonia**
californica, *Torr.*

**Dracæna**
phrynioides, *Hook. fil*

**Drosophyllum**
lusitanicum, *Link.*

**Drosera**
capensis, *Linn.*
filiformis, *Rafin.*
peltata, *Sm.*
rotundifolia, *Linn.*
spathulata, *Labill.*

**Eucalyptus**
ficifolia, *F. Muell.*
urnigera, *Hook. fil.*

**Ficus**
diversifolia, *Blume.*

**Fuchsia**
procumbens, *R. Cunn.*

**Gazania**
pygmæa, *Sond.*

**Genista**
monosperma, *Lam.*

**Gossypium**
arboreum, *Linn.*
herbaceum, *Linn.*
neglectum, *Tod.*

**Heeria**
rosea, *Triana.*

**Hedychium**
Gardnerianum, *Rosc.*

**Hibiscus**
esculentus, *Linn.*
lunariifolius, *Willd.*
Manihot, *Linn.*
pedunculatus, *Linn.*

**Humea**
elegans, *Sm.*

**Hydrolea**
spinosa, *Linn.*

**Kalanchoe**
crenata, *Haw.*
thyrsiflora, *Harv.*

**Kennedya**
prostrata, *R. Br.*

**Lycopersicum**
Humboldtii, *Dun.*
racemigerum, *Lange.*

**Maurandia**
Barclayana, *Lindl.*

**Melothria**
cucumerina, *Naud.*

**Mesembryanthemum**
blandum, *Haw.*
curviflorum, *Haw.*
elegans, *Jacq.*
micans, *Linn.*
polyanthon, *Haw.*
roseum, *Willd.*

**Mimosa**
marginata, *Lindl.*
pudica, *Linn.*

**Mimulus**
glutinosus, *Wendl.*

**Momordica**
Charantia, *Linn.*
cochinchinensis, *Spreng.*

**Musschia**
Wollastoni, *Lowe.*

**Myrtus**
communis, *Linn.*
Luma, *Barn.*
Ugni, *Mol.*

**Nephthytis**
liberica, *N. E. Br.*

**Nicotiana**
sylvestris.

**Ochna**
Kirkii, *Oliv.*
mossambicensis, *Klotzsch.*

**Ornithogalum**
lacteum, *Jacq.*

**Orthosanthus**
multiflorus, *Sweet.*

**Oryza**
sativa, *Linn.*

**Oxypetalum**
cæruleum, *Decne.*

**Passiflora**
edulis, *Sims.*
quadrangularis, *Linn.*

**Pelargonium**
ternatum, *Linn.*

**Pentas**
carnea, *Benth.*, var. kermesina, *Hort.*

**Phyllanthus**
montanus, *Sw.*

**Pinguicula**
lusitanica, *Linn.*

**Polyalthia**
suberosa, *Benth.* et *Hook. fil.*

**Primula**
floribunda, *Wall.*
mollis, *Nutt.*
verticillata, *Forsk.*

**Psychotria**
micrantha, *Hiern.*

**Ricinus**
communis, *Linn.*

**Rivina**
humilis, *Linn.*

**Sarracenia**
illustrata, *Hort.*

**Senecio**
macroglossus, *DC.*

**Solanum**
Seaforthianum, *Andrews.*

**Tacsonia**
mixta, *Juss.*

**Tetranema**
mexicana, *Benth.*

**Tillandsia**
splendens, *Brongn.*

**Torenia**
flava, *Buch.-Ham.*
Fournieri, *Linden.*

**Turnera**
ulmifolia, *Linn.*

**Villamilla**
octandra, *Hook. fil.*

**Vitis**
heterophylla, *Thunb.*, var. humulifolia, *Hort.*

Number III.

# NOTES

FROM THE

# ROYAL BOTANIC GARDEN, EDINBURGH.

DECEMBER 1900.

CONTENTS.



GLASGOW:
PRINTED FOR HIS MAJESTY'S STATIONERY OFFICE
BY JAMES HEDDERWICK & SONS,
AT "THE CITIZEN" PRESS, ST. VINCENT PLACE.

SOLD AT THE GARDEN,
And to be purchased, either directly or through any Bookseller, from
OLIVER & BOYD, EDINBURGH.

[PRICE NINEPENCE.]

# Observations on the Girth-increase of Trees in the Royal Botanic Garden, Edinburgh, for Twenty Years, 1878-1897.

BY

DAVID CHRISTISON, M.D.

## PART I.—DECIDUOUS TREES.

THE late Sir Robert Christison, when nearly four score years of age, began in 1875 a series of girth-measurements of trees on scientific principles in order to ascertain their annual girth-increase, and was, I believe, the first to do so. The observations for the first three years were initiatory upon a few trees only, but in 1878 systematic observations were begun on a much larger number. In a series of papers read to the Botanical Society of Edinburgh in 1878, 1879, 1880, and 1881, he explained his methods, gave the results of his observations, and showed the practical uses to which such observations could be put. One of these,—the rather elaborate computation of the age of trees from a series of girth-measurements in a particular tree and in others of the same species at different sizes,—has been superseded by the process of extracting borings on which the annual rings can be counted, and for practical purposes the same ready method is applicable in determining the present rate of growth of a stem; but for this purpose it is necessary to take the average of several borings in the circumference of the tree, and girth-measurements probably yield more precise results in determining, not only annual increments, but more particularly the finer rates for months or even shorter periods. It must always be remembered, however, that such measurements show

simply the increase in girth, and cannot discriminate between the amount due to deposit of wood on the one hand, or to changes in the bark or cambium on the other. In this respect borings have the advantage, but as to the bark I may state generally that except in very old trees there seems to be little loss in mass, or even by gradual attrition—so little as to be inappreciable in a single year. Thus, even in old rough-barked trees, my painted distinguishing numbers often show little trace of wearing in ten or twelve years, although distorted and rendered illegible from the gradual widening and splitting of the bark. Notable exceptions among the species are the true Plane tree and the Yew, whose tendency to shed their bark is so manifest.

Sir Robert Christison at first aimed at no finer division of his tape than tenths of an inch, and confined himself to annual observations, but very soon, with practice and improved tapes, he measured to the twentieth of an inch and took monthly observations. Since his death in 1882, I have continued to measure his original trees, but as many of them, even from the first, were old or prematurely old, it was evidently desirable to experiment on younger specimens, not only because the results would be probably more reliable, but in order to ascertain the increments of the species over a greater range of age. Accordingly, in 1887, I selected some thirty-five young deciduous trees, from six to twenty inches in girth, chiefly situated in the South and East shelter belts of the Arboretum, and a similar number of young Pinaceæ in the Botanic Garden, taking two of each species when possible, so that in case of one failing the other might preserve the continuity of observations in the species. With the exception of a few that were cut down from death or degeneracy, all of this second set were observed annually till the end of the period, and monthly from 1887 to 1891. The deciduous specimens generally throve well, considering that they had been put in without preparation of the naturally poor sandy soil, before the Arboretum was handed over to the authorities of the Garden, but they were almost all transplanted after 1891, and thus the continuity of observations was interrupted. The Pinaceæ, again, throve so badly as greatly to mar the value of the results in them.

To compensate for this interruption in the deciduous group, I selected in 1892 a fresh set of twenty young trees, each of a different species, almost all growing in the North and West borders of the Arboretum, subject to the same objection of want of preparation of the ground before planting as the former set, but favoured by a rather better soil. Once more, however, the continuity of observation was interrupted, in 1896, by a close pruning of branches and roots, in preparation for transplantation, which at once reduced the aggregate girth-increase by nearly one-half. As to the Evergreens, discouraged as I was by the comparative failure of the first set, I made no effort to increase their number, although the observations on the original set were continued.

The introduction of Chesterman's steel tapes insured an accuracy of measurement unattainable in the original experiments, and enabled me to initiate new inquiries, such as the determination, within narrow limits, of the seasonal beginning of girth-increase in the different species, the weekly rate of growth, the relation of girth-increase to the development of the leaves and twigs, &c.; and the various results were communicated to the Royal Society of Edinburgh in 1883, and to the Botanical Society in 1887, '88, '89, and '92. In the present Report I shall confine myself to the annual and monthly results,—and in the deciduous trees only,—bringing them down to 1897, which completes a period of twenty years. The observations for 1892–97, both annually and monthly, and the annual observations of the original set for the second decade, which have not yet been published, will be given in detail, but only the general results for the first decade are reproduced from my former papers. In these papers were incorporated observations made on trees at Craigiehall, near Cramond, but these have long been discontinued, and the results will only be incidentally used here. Thus, the present Paper becomes peculiarly a record of the life-history, as indicated by girth-increase, of a considerable number of deciduous trees in the Botanic Garden and Arboretum, over periods of from six to twenty years.

Doubts have been expressed as to the possibility of measuring the girth of trees to the twentieth of an inch with accuracy, and unquestionably in stems of great size, and in all stems of irregular

form or with very rough bark, an error of the twentieth or even the tenth of an inch may be caused by the slightest shifting of the tape. But such trees should be rejected, at least for fine or frequent observation, and if we select young cylindrical stems with smooth bark, or even when it is rough, provided the roughness be regular and free from excrescences, it is possible, by adopting careful methods, and with practice, to attain a wonderful degree of accuracy. I have frequently checked an observation on such trees by repeating it three times, using a fine millimetre tape, and found a variation of not so much as half a millimetre. The method adopted by me is fully explained under the next head.

## GENERAL EXPLANATIONS.

1. METHOD OF TAKING OBSERVATIONS.—The measured point, generally five feet above ground, is marked in white paint by several short horizontal lines round the stem. A short perpendicular line at one of them that occupies the most prominent position marks the spot where the measurement begins.

Chesterman's steel tapes are used, one, graduated to twentieths of an inch, for ordinary observations, and another, of more slender make, graduated to millimetres, for finer work. In both, the ordinary ring is replaced by a square, slightly wider than the tape, and included in the graduation.

In small stems the tape is held in position at the fixed starting point with the nail of the forefinger of the left hand, and the tape is passed round the stem with the right hand, and brought fairly over the square, which can be accurately done, as the square is wider than the tape. The amount is then read off at the outer edge of the square. For larger stems the process is the same, except that, to allow the observer to go round the tree, the square is kept in place by a "brog," which must be removed, the square being kept in position with the nail of the forefinger, in order that the measurement may be read off accurately.

2. THE GIRTH OF A TREE usually signifies its circumference at five feet from the ground, or, in a short stem, at its narrowest point. But five feet was the height aimed at for observation whenever it was practicable.

3. HEIGHT OF MEASUREMENTS.—When trees were too young to be measured at five feet, a convenient point was chosen two or three feet from the ground, and as the trees grew and became fit, the point was raised to the five-feet level. I do not think the results were in any way invalidated by this necessary compromise.

4. SUMMING-UP OF TABLES.—The entries in the Tables of increments due to years in which trees were temporarily ineligible, from the effects of transplantation or pruning, are printed in *italics*, and such entries are not included in the summing of the lines and columns.

5. SCALE USED FOR MEASUREMENTS.—All measurements are in inches and decimal parts of an inch unless otherwise stated.

## I. ANNUAL RESULTS.

Following the plan formerly adopted, I take first the results for the species separately, and then the collective results. To preserve the convenience of division into decennial and quinquennial periods, I have omitted from the Tables the first year's observations on the second set of trees, but they will be available in the text, and will be fully given in the monthly division of the subject.

The chief results derived from the annual observations are—

1. The annual rate of girth-increase in the species at different ages;
2. The seasonal range in the species separately; and
3. The same in the aggregate.

The seasonal variations ought to be considered in connection with meteorology, but an inquiry of this kind is complicated by the variety of influences that come into play, such as the ripening of the wood, the formation of the buds, low temperatures of the air or earth, the protective or destructive effects of snow, sudden thawing, excessively low temperature, excess or defect of rain or humidity, &c., besides the effects of position in sheltering or exposing different trees to these weather influences. To have done justice to all these points would have taken far more time than I had at my command. I have been content therefore to

deal only with instances in which the cause of a marked depression was not far to seek. None such occurred in the second decade, but the first was signalised at the outset by an unprecedented series of three most unfavourable seasons, chiefly owing to exceedingly low winter temperatures, which reduced the aggregate increment by nearly one-half, and affected some trees for years afterwards, if not permanently. The disastrous effects on girth-increase of these seasons have been described in former papers by my father* and myself,† and will be only incidentally mentioned now.

## A. General History of the Species Separately.

In place of taking the species in scientific sequence, it was deemed preferable to deal with them in the order of the reliability of the observations, whether depending on the larger number of observations, or on the better thriving of the species in the soil of the Garden. A certain preference has also been given to the importance of the species as forest trees.

Each Table is drawn up so as to show—

(1) The following results in the original adult or old trees of 1878:—*a.* The average increase in girth for the first decade for each tree under observation. *b.* The annual increase in detail for the second decade. *c.* Its total amounts and its average annual rate. *d.* The girth of each tree at the end of the decade in 1897.

(2) The same details, as far as they go, in the second decade for the younger trees selected in 1887 and 1892, given at the foot of the Tables.

* *On the Exact Measurement of Trees*, Part 4. Trans. Bot. Soc. Ed., 1880.

† *Op. cit.*, 1880-89, p. 397. The Depression in Girth-Increase of 1879, 1880, and 1881; *et passim*.

[TABLE.

## FAGUS SYLVATICA.

| No. in List. | Av. Annual Rate, 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Rate. | Girth, Oct. 1897. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894 | 1895. | 1896. | 1897. | | | |
| 7 | 1·03 | ·75 | ·80 | ·95 | ·90 | 1·20 | 1·10 | ·85 | ·60 | ·90 | ·80 | 8·85 | ·88 | 89·60 |
| 8 | 0·99 | ·80 | ·95 | ·95 | ·90 | ·90 | ·90 | ·90 | ·90 | 1.10 | ·90 | 9·20 | ·92 | 79·50 |
| 14 | 0·48 | ·40 | ·35 | ·20 | ·25 | ·30 | ·25 | ·45 | ·30 | .25 | ·30 | 3·05 | ·30 | 83·70 |
| 38 | 0·43 | ·30 | ·25 | ·25 | ·25 | ·40 | ·25 | ·45 | ·25 | ·40 | ·25 | 3·05 | ·30 | 67·75 |
| | | 2·25 | 2·35 | 2·35 | 2·30 | 2·80 | 2·50 | 2·75 | 2·05 | 2·65 | 2·25 | | | |
| 97 | .. | 1·15 | 1·30 | 1·50 | 1·30 | Died after Transplantation. | | | | | | 5·25 | 1·31 | 15·55 |
| 98 | .. | 1·00 | 1·10 | 1·45 | 1·35 | 1·55 | Do. | | | | | 6·45 | 1·29 | 14·55 |
| 20 | .. | .. | .. | .. | .. | .. | 1·70 | 1·45 | ·20 | *·60** | *·55* | 4·35 | 1·45 | 20·95 |

* See Explanation of Figures, page 44.

I have placed this species first, because the Beech here, as in Scotland at large, thrives better perhaps than any other of our forest trees.

The two first in the Table, handsome and healthy looking trees, stand free in the low ground where the original Botanic Garden bordered the former Horticultural Garden. Reckoning in round numbers, they have increased in girth, No. 7 from six feet to seven and a half feet, No. 8 from five feet to six and a half feet, in twenty years, and the annual rate in each has been ·95. But the rates in the first decade were 1·03 and ·99, and in the second ·88 and ·92 respectively, showing an appreciable decline, which, however, was not steady, for if we take the total increments for the two trees in quinquennial periods they come out—9·70, 10·35, 8·95, 8·95. The inferiority of the first to the second quinquennial period is explicable by the depressing effect of the low temperatures in 1879, 1880, and 1881, which, although they affected this species less than any other, still left their mark upon it for three years. Thus, the united increase of Nos. 7, 8 was 2·40 in 1878 and only 1·75, 1·55, and 1·75 in the three following years. The marked decline in the third quinquennium from 10·35 to 8·95 cannot be explained unless on the theory that the trees had passed the maximum of their growing power, but the rate underwent no further fall in the fourth quinquennium.

The *annual range* in these two trees differed remarkably. In No. 7 it was ·60 to 1·20, in No. 8 ·80 to 1·20. But the extremes do not show the difference sufficiently. If we take, for example, the seven years 1889-95, the range in No. 7 was ·60 to 1·20, and in No. 8 only ·90 to ·95. It is difficult to understand this difference in two trees of much the same size, growing at the same rate, and within fifteen yards of each other, unless it may be due to No. 7 standing quite free, whereas No. 8, although not pressed upon, has trees and shrubs near it, and is more closely sheltered.

Nos. 14, 38 were much the same size respectively as Nos. 7 and 8 when they were all first measured in 1878, but have fallen behind in the race, their rates in the first decade having been only ·48 and ·36, and in the second being reduced in both to 0·30, the average for the twenty years being 0·39 and 0·36, or considerably less than half that of Nos. 7 and 8. This may be accounted for by their position, on the South of Inverleith House, on a high site and probably in inferior soil. They are tall and handsome enough, but have not the fine heads of the other two. The variations in their history have been much the same as in Nos. 7 and 8, the results for their quinquennial periods being 4·80, 4·55, 3·10, 3·25, showing the same fall as in the other two in the third period, not progressing in the fourth.

The *annual range* in No. 14 was ·25 to ·65, and in No. 38 ·15 to ·60.

Taking the four trees together, the range in the first decade was considerably greater than in the second, owing to the disturbing influence of the low temperatures in 1879, 1880, and 1881. In the first decade it was 1·95 to 3·60 and in the second it was only 2·05 to 2·80.

The career of the young beeches, Nos. 97 and 98, was unfortunately soon cut short by death after transplantation, and that of No. 20 temporarily interfered with by pruning, but the *average annual rate* of the three, 1·34, was considerably above that of the best of the older trees. Their *range* in the twelve available records was 1·00 to 1·70.

[TABLE.

## QUERCUS ROBUR.

| No. in List. | Girth at first. | Annual Increments. | | | | | | | | | | Total Incr. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 1 | 5·50 | ·40 | ·40 | ·65 | ·75 | ·70 | ·45 | ·50 | *·10* | *·15* | ·60 | 4·45 | ·56 | 10·15 |
| 2 | 8·00 | ·20 | ·30 | ·65 | ·80 | ·90 | ·90 | ·60 | ·45 | *·5* | *·10* | 4·70 | ·59 | 11·70 |
| 70 | 7·95 | ·50 | ·75 | ·95 | 1·05 | 1·20 | 1·00 | ·75 | 1·05 | ·80 | dead. | 8·05 | ·89 | 13·90 |
| 72 | 6·40 | ·20 | ·40 | ·80 | ·55 | 1·15 | 1·05 | 1·00 | ·40 | ·60 | do. | 6·15 | ·68 | 11·55 |
| 10 | 11·60 | .. | .. | .. | .. | .. | ·75 | ·65 | ·35 | *·20* | *·25* | 1·75 | ·58 | 13·85 |

The native Oak does not show to much advantage in the Edinburgh district, and the specimen put under observation in the Garden in the first decade, and that only from 1880 (not in the Table), was a short-stemmed spreading tree, on the west slope from Inverleith House, that had lost many branches and become misshapen. It was by a long way the patriarch of the oaks in the Garden, having attained the respectable girth of eight feet. It increased in nineteen years from 95 to 99 inches in girth, or at the annual rate of ·22, more than, from its appearance, I should have expected, but it is not desirable to give the details, as from the small increments and the rough bark they are not reliable.

The four young trees Nos. 1, 2, 70, and 72, placed under observation in 1888, and No. 10, begun in 1893, yielded annual rates varying from ·56 to ·89, the average of the whole being ·66; but if we leave out the three first years when they were very young, and the last three, when those that were still eligible had, for some unknown reason, begun to fail, the average rises to ·84, and the annual rate of No. 70, the quickest grower, in its six best years, 1890–95, was exactly one inch.

The best of those is probably a poor rate compared with what might be expected in young oaks under more favourable circumstances, for even near Edinburgh, at Craigiehall, a tree, ten feet in girth at the beginning of the first decade, yielded a rate of 0·69 for ten years.

The aggregate increases of the four first on the list for the seven available years 1888–94 were 1·30, 1·85, 3·05, 3·15, 3·95,

3·40, 2·75. These figures probably represent a natural rise from extreme youth in the first two years to an equilibrium for the next four years, but there seems to have been a depression in the seventh year, followed by the death of two of the trees.

The *range* is very high, as might be expected from the erratic history, and cannot be regarded as normal. Even in No. 70 it was ·50 to 1·20, or taking the six steadiest years ·75 to 1·20.

## OTHER SPECIES OF QUERCUS.

### QUERCUS CONFERTA.

| No. in List. | Annual Av., 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 40 | 1·65 | 1·05 | 1·20 | 1·35 | 1·25 | 1·70 | 1·80 | *·90* | *1·30* | *·50* | *·60* | 8·35 | 1·39 | 51·80 |
| 54 | 1·70 | 1·30 | 1·75 | 2·05 | 1·50 | 1·75 | 2·30 | *1·05* | *1·25* | *·65* | *·0* | 10·65 | 1·77 | 43·35 |
| 55 | 1·57 | 1·30 | 1·55 | 1·65 | 1·30 | 1·70 | 2·10 | *·75* | *1·25* | *·65* | *·5* | 9·60 | 1·60 | 39·05 |
| | | 3·65 | 4·50 | 5·05 | 4·05 | 5·15 | 6·20 | *2·70* | *3·80* | *1·80* | *·65* | | | |

The Hungary Oak is much more at home in the Botanic Garden than its native cousin, at least in early youth; indeed, with the exception of the Willow, it has proved the quickest growing species of all that were under observation. Unfortunately for my purposes, owing to a liberal pruning to promote upward growth, the results became unavailable for the last four years of the second decade, but in the first decade the rates of the three trees were 1·65, 1·70, and 1·57, and in the third quinquennium with the one available year of the fourth they were 1·39, 1·77, and 1·60, the respective girths attained being four feet four inches, three feet seven inches, and three feet three inches. Of the 44 recorded measurements not one fell to an inch, the lowest being 1·05, while two inches and upwards was reached five times, the highest being 2·30. The great and progressive depression caused by pruning has been such that, while in 1893 the aggregate increase was 6·20, in 1897, four years afterwards, it was only ·65, yet the trees look healthy and well clothed, with the exception of No. 40, which for a year or two before the pruning had looked rather scraggy.

The aggregate annual increments for fourteen years were 3·60, 5·15, 5·25, 5·40, 5·05, 4·85, 4·65, 5·30, 3·65, 4·50, 5·05, 4·05, 5·15, 6·20. They were generally therefore pretty steady, but two marked depressions occurred. The first, in the year of the first record, 1880, when the fall, to 3·60, was probably due to the severe previous winter; the second, 3·65, was in 1888, from some unknown cause. The highest record, 6·20, was in 1893, the year before the changes produced by pruning.

The range in the trees individually was from 1·05 to 1·85 in No. 40, 1·10 to 2·30 in No. 54, and 1·10 to 2·10 in No. 55, but excluding the two years of marked depression the figures are 1·20 to 1·85, 1·60 to 2·30, and 1·20 to 2·10.

QUERCUS CERRIS.

| No. in List. | Annual Av., 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 43 | ·57 | ·50 | ·30 | ·70 | ·60 | ·70 | ·65 | ·60 | ·50 | ·70 | ·55 | 5·80 | ·58 | 53·50 |
| 63 | .. | ·70 | ·45 | ·65 | ·50 | ·70 | ·85 | ·70 | ·55 | ·80 | ·60 | 6·50 | ·65 | 67·15 |
| 15 | .. | .. | .. | .. | .. | .. | ·70 | ·65 | ·70 | ·65 | ·65 | 3·35 | ·67 | 10·00 |
| | | 1·20 | ·75 | 1·35 | 1·10 | 1·40 | 2·20 | 1·95 | 1·75 | 2·15 | 1·80 | | | |

The Turkish Oak, although it grows at a much less rate than the last, is another species that thrives much better in the Garden than the native tree, and that to a considerable size; indeed, there are few handsomer trees than No. 63 growing free in the centre of the Garden, and now upwards of five feet and a half in girth. The other tree, No. 43, is also tall and handsome, but, although only four and a half feet in girth, is growing at a somewhat slower rate than No. 63, perhaps because it is in the East border and has not the freedom of its brother. The rate of No. 43 in the first decade was ·57, and in the second it was even a trifle higher. No. 63 in the first quinquennium of the second decade had a rate of 0·60, and in the second 0·70, so that it seems to be increasing rather than diminishing in vigour. The very young No. 15, in the North border of the Arboretum, measuring only six and a half inches in girth, when put under observation

in 1893, had much the same rate, ·67, in the second. quinquennium of the second decade.

In the aggregate returns the only traceable depression was in 1889, when the two trees then available grew only ·75. Deducting this year, the growth was pretty steady, the extremes in the last five years, when all three were available, being 1·80 and 2·20.

The *range* of No. 43 for the two decades was ·30 to ·70, but removing two depressed years,—1881, when the tree suffered from the low temperatures of the winter, and 1889,—the range was only ·50 to ·70. With deduction of 1889, that of No. 63 in the second decade was also ·50 to ·70, and that of No. 15 in the fourth quinquennium was only ·65 to ·70.

The species appears to thrive even better in the vicinity of Edinburgh. Thus, a fine specimen at Craigiehall, when nearly seven feet in girth in 1890, had been growing at the rate of ·89 for eleven years; and a very fine healthy tree at Cramond House, measured by Sir Robert Christison in 1878, girthed no less than 12 feet 8 inches at the narrowest part of the stem, five feet above ground.

## QUERCUS PALUSTRIS.*

* Erroneously called *Q. rubra* in former papers, from a mistake in the label on the tree.

| No. in List. | Annual Av., 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 44 | ·45 | ·40 | ·30 | ·50 | ·35 | ·45 | ·40 | ·55 | ·40 | ·35 | ·25 | 3·95 | ·39 | 39·20 |

This species does not seem to do so well; at least the largest in the Garden, No. 44, now only three and a quarter feet in girth, grew at the low rates in the first decade of ·45 and in the second of ·39. It was noted since 1880 as having a shabby look, with many dead twigs.

## QUERCUS RUBRA.

| No. in List. | Annual Av., 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 61 | .. | .. | .. | ·90 | 1·00 | 1·15 | 1·50 | 1·25 | *·55* | *·50* | *·35* | 5·90 | 1·18 | 12·35 |

This American Oak, on the other hand, seems to excel the native species in its rate. At least the young No. 61, after fully recovering from transplantation, averaged 1·18 for five years, when it became temporarily ineligible from re-transplantation.

## QUERCUS ILEX.

| No. in List. | Annual Av., 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 45 | ·28 | ·45 | ·40 | ·60 | ·55 | ·55 | ·70 | ·15 | ·20 | ·0 | ·5 | 3·65 | ·36 | 47·55 |
| 46 | ·23 | ·40 | ·40 | ·45 | ·30 | ·25 | ·45 | ·15 | ·25 | ·25 | ·5 | 2·95 | ·29 | 34·05 |
| 16 | .. | ·55 | ·80 | ·85 | ·50 | ·60 | ·65 | ·15 | ·25 | ·45 | ·35 | 5·15 | ·51 | 9·85 |

In my paper of 1888 it is remarked that no species suffered more from the three severeseasons than the Evergreen Oak. The largest in the Garden, upwards of six feet in girth, lost two years' growth of twigs, recovered its foliage slowly and imperfectly, some large limbs requiring to be cut off, and has quite lost its handsome, shapely form. Nos. 45, 46 did not suffer so badly, but their girth-increase was reduced to a mere nothing in 1880 and 1881. Afterwards they rallied somewhat till 1894, when they suddenly failed and almost ceased to grow. No. 45 seems now to be dying. It is remarkable that the infant specimen, No. 16, in the oak grove of the Arboretum, suffered a serious diminution in girth-increase in the same year, so that it would seem that all three had been then subjected to some common evil influence. The rate of No. 16 in the first quinquennium was no less than ·66, although it was a mere infant, girthing only 4·65 inches at fifteen inches above ground, when measured at the beginning of the period. In the first year of the second quinquennium it maintained this average, but in 1894 the rate fell to ·15, and there has been no full recovery since, so that the rate for the second quinquennium has been only ·37, or little more than half that of the first. At the same time, the tree has never looked ill, and it is now a remarkably thriving and vigorous looking specimen.

ACER PSEUDOPLATANUS.

| No. in List. | Annual Rate, 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 13 | 0·26 | ·25 | ·20 | ·2 | ·30 | ·30 | ·25 | ·25 | ·30 | ·10 | ·25 | 2·45 | ·24 | 136·50 |
| 28 | ·35 | ·20 | ·20 | ·30 | ·10 | · 5 | ·25 | ·15 | ·15 | ·35 | ·15 | 2·20 | ·22 | 64·25 |
| 71 | .. | ·85 | 1·05 | 1·40 | 1·20 | 1·40 | 1·30 | 1·30 | 1·00 | 1·00 | *·0* | 10·50 | 1·17 | 19·90 |
| 74 | .. | ·70 | 1·10 | 1·55 | 1·40 | 1·55 | 1·40 | 1·45 | 1·55 | *·15* | *·30* | 10·70 | 1·34 | 19·25 |
| 67 | .. | .. | .. | ·50 | ·40 | ·65 | ·75 | ·95 | ·70 | 1·05 | ·85 | 5·85 | ·73 | 11·40 |
| 16 | .. | .. | .. | .. | .. | ·20 | 1·40 | 1·20 | .. | *·15* | *·5* | 3·80 | 1·27 | 16·10 |

The Sycamore grows fairly well near Edinburgh, although it is rarely seen in the city gardens, and the largest trees in the Arboretum are of this species. Trees at several ages were tested. No. 67, only about a foot in girth in 1897, had grown at the rate of ·73 for eight years; Nos. 16, 71, and 74, girthing one foot four to one foot eight inches in 1897, had grown, the first for three, the second for nine, and the third for eight years, at the rates of 1·26, 1·17, and 1·34, or on an average 1·26. These younger trees were only under observation in the second decade.

No. 28, now five feet four inches in girth, was chosen in 1878 as a handsome and thriving tree in a plantation belt opposite the Palm House, but, although it continued to look well, its rate all along has been surprisingly low, only ·35 in the first decade and ·22 in the second, or not much above a quarter of an inch annually for twenty years.

The veteran, No. 13, chosen by Sir Robert in 1878, perhaps because it was the largest tree of any kind in the Garden, although even then past its best, is still presentable, and girths nearly eleven and a half feet. Its rough and scaling bark renders it unreliable for single years, but the average rate for the first decade was ·26 and for the second ·24, showing no very perceptible decline, and scarcely less, on the whole, than that of No. 28, which has just half its girth.

The range of No. 67, the youngest specimen, was great, ·50 to 1·05, but that is, no doubt, because it was only growing out of

infancy. Deducting the year 1888, which appears to have been unusually unfavourable to Nos. 71 and 74, the range of these two and of No. 16 in eighteen records was moderate, 1·00 to 1·55.

## ACER CAMPESTRIS.

This young Maple, No. 12, at the N.-W. corner of the Arboretum, has only been under observation since 1892, and its increments have been 1·60, 1·30, 0·85, 1·55, 1·00, and ·90, giving an average of 1·20, the girth being now twenty inches. Since 1896 the tree has not looked so healthy as at first, possibly the result of pruning, although it was not excessive. The increase has been very erratic, and the range, ·85 to 1·60, is high for so short a period.

## ŒSCULUS HIPPOCASTANUM.

| No. in List. | Annual Av. 1st Decade. | ANNUAL INCREMENTS. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 9 | ·33 | ·35 | ·5 | ·10 | 00 | ·25 | ·10 | ·25 | ·25 | ·30 | ·00 | 1·65 | ·16 | 53·75 |
| 73 | .. | ·70 | 1·10 | ·90 | ·80 | ·85 | ·90 | ·75 | ·60 | ·25 | ·60 | 6·60 | ·82 | 11·85 |
| 80 | .. | 1·05 | 1·35 | 1·30 | 1·15 | ·10 | ·40 | ·55 | 1·25 | 1·25 | ·95 | 8·30 | 1·19 | 15·45 |
| 4 | .. | .. | .. | .. | .. | 1·35 | 1·40 | 1·05 | 1·05 | ·75 | ·60 | 4·85 | 1·21 | 19·00 |

No. 9, the only Horse Chestnut observed in the first decade, was somewhat crowded, but had a fair head of foliage, and was four feet in girth. In 1878 the girth-increase was 0·70, but it suffered a decided fall from the very low temperatures of the next two winters, only to rally again to 0·70 in 1881. Next year, from some cause that affected the species universally near Edinburgh, the foliage withered in May, but it revived next year, and has been dense and healthy ever since. Nevertheless, the average increase for the six years following 1882 was only 0·17, and for the next ten 0·16. In twenty years it has increased only five inches. Is the singular fact of apparent healthiness and vigour, along with an extremely low rate, the prolonged effect of the disease of 1882? Or may it be due to the over-

topping of it by a neighbouring tree, although this cause could not have operated at first? Of the two very young trees, Nos. 73, 80, growing near each other in the South border of the Arboretum, the first has proved inferior to the second, although of the same age, the rate of No. 73 having been ·81 and of No. 80 1·19. That of No. 4, a somewhat older tree in the North border, was 1·21, when its career was interrupted by pruning, as that of the other two had been by transplantation.

The range was moderate in them all, ·60 to 1·10 in No. 73; ·95 to 1·35 in No. 80; and 1·05 to 1·40 in No. 4.

## ULMUS MONTANA.*

* Erroneously named U. campestris in my former paper.

| No. in List. | Annual Increments. | | | | | | | | | | Total. | Annual Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 93 | 1·75 | 1·80 | 1·75 | 1·50 | 1·30 | 1·70 | 1·60 | 2·05 | 1·75 | 1·35 | 16·55 | 1·65 | 30·75 |
| 94 | 1·15 | 1·75 | 1·50 | 1·30 | *·10* | *·30* | *·80* | 1·55 | 1·60 | 1 20 | 10·05 | 1·43 | 22·30 |
| | 2·90 | 3·55 | 3·25 | 2·80 | .. | .. | .. | 3·60 | 3·35 | 2·55 | .. | .. | .. |

In the Edinburgh city gardens the Wych Elm resists the deleterious influences of town life better than any other species. In the Botanic Garden there is no specimen of considerable size, and thus it happened that Sir Robert did not experiment on the species, and I have no records in the first decade. In the second the two healthy young trees, Nos. 93, 94, in the Arboretum have done remarkably well, the former yielding an annual rate of 1·65 for ten years, the latter 1·43 for seven years, the other three years of its decade having been employed in making up the loss sustained by transplantation. Not one of the seventeen records falls to one inch.

The *range* has been moderate, 1·30 to 2·05 in No. 93 and 1·15 to 1·75 in No. 94, and there has been no marked depression, although both trees were almost at their lowest rate in 1897, the united increments being 2·55. The best year was 1895, with 3·60, being an average of 1·80, but several other years were nearly as good.

## ULMUS CAMPESTRIS.

This great ornament of the South-west of England makes but a poor show in Scotland, where it is scarcely recognisable as the same tree. Two tall, lanky, but well-clothed specimens in the Botanic Garden, however, girth 58 and 59 inches. A quite young one was selected in the Arboretum in 1892, when it girthed 9·60 inches. The increases for the next four years were only ·75, ·60, ·55, and ·50, yielding a rate little over half an inch, and as it had a very shabby appearance it was cut down.

## TILIA EUROPŒA.

| No. in List. | Annual Av., 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 2 | ·30 | ·00 | ·50 | ·40 | ·25 | ·20 | ·40 | ·35 | ·00 | ·30 | ·35 | 2·75 | ·27 | 81·50 |
| 18 | ·35 | ·30 | ·15 | ·55 | ·15 | ·45 | ·65 | ·45 | ·10 | ·40 | ·00 | 3·20 | ·32 | 49·40 |
| 69 | .. | ·60 | ·85 | ·75 | ·55 | 1·00 | ·90 | ·70 | ·70 | ·85 | *·00* | 6·90 | ·77 | 12·60 |
| 85 | .. | ·50 | 60 | ·65 | ·45 | ·75 | ·70 | ·55 | ·50 | ·60 | *·05* | 5·30 | ·59 | 11·45 |
| | | 1·40 | 2·10 | 2·35 | 1·40 | 2·40 | 2·65 | 2·05 | 1·30 | 2·15 | .. | | | |
| 3 | .. | | | | | 1·35 | 1·45 | 1·25 | ·90 | *·60* | *·50* | 4·55 | 1·24 | 19·90 |

The fine spreading Lime, No. 2, stands free in the centre of the Botanic Garden, and is one of its best trees. It increased in the first decade at the rate of ·30 and in the second ·27, a slow progress; but it looks healthy, and is approaching seven feet in girth.

No. 18, although only four feet in girth, has nearly as poor a rate. Possibly it has been permanently checked by the low temperatures in the winter of 1879, as it fell in that year to ·40 from ·70 in 1878, and in the two following years was only ·15 and ·25. Although it may have been somewhat crowded formerly it has not been so when under observation, and it is now a well-formed, healthy-looking tree, so that its continued low rate is somewhat mysterious. It has recently, 1899, been transplanted a short distance, and now stands quite free,

The rates of the quite young Nos. 69, 85 are only ·77 and ·59, and seem poor compared with those of most other forest trees in the Garden, but No. 3, not much older, averaged 1·24 in four years, so that the conduct of Nos. 69, 85 may be exceptional.

In the species there seem to have been years of depression in 1888, 1891, and 1895.

The range in the young trees was not excessive, ·55 to 1·00, ·50 to ·75, and ·90 to 1·35.

## FRAXINUS EXCELSIOR.

| No in List. | ANNUAL INCREMENTS. | | | | | | | | | | Total. | Annual Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 23 | ·85 | 1·15 | ·90 | ·80 | *·30* | *·25* | 1·05 | 1·40 | 1·0 | *·20* | 7·35 | 1·05 | 14·70 |
| 75 | ·45 | ·60 | ·45 | ·65 | ·65 | ·65 | ·60 | *·5* | *·25* | ·50 | 4·55 | ·57 | 9·40 |
| 2 | .. | .. | .. | .. | 1·30 | 1·10 | 1·20 | 1·25 | *·65* | *·45* | 4·85 | 1·21 | 18·25 |

This species was not observed in the first decade. In the second the two very young trees, Nos. 23, 75, of nearly the same girth, and growing in the same circumstances in the South border of the Arboretum, fared so differently that No. 23, with an average of 1·05, grew at nearly twice the rate of No. 75. Both were transplanted during the decade, No. 23 twice. No. 2, a somewhat older tree in the West border, had a rather better rate than No. 23, or 1·21. The ranges were moderate, ·85 to 1·40, ·45 to ·65, and 1·10 to 1·30.

## FRAXINUS ORNUS.

This flowering Ash, a graft on a two-foot stool of the common Ash, and a transplant from the older Garden of 1822, was a handsome and flourishing tree about six and a quarter feet in girth in 1878, and grew at the rate of ·41 in the first decade. It still looks fairly well, but girth-increase almost ceased in the second decade, the total being less than an inch. The girth in 1897 was 80·30, and that of the stool at its narrowest 107·50.

CASTANEA VESCA.

| No. in List. | Annual Rate, 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 4 | ·94 | ·60 | ·75 | 1·00 | ·60 | ·90 | ·90 | ·40 | ·80 | ·45 | ·55 | 6·95 | ·69 | 87·20 |

This rather handsome tree grew at the rate of nearly an inch annually in the first decade, and was little affected by the low temperatures of 1879, 1880, and 1881. In the third quinquennium, however, the rate fell to ·77, and in the fourth to ·62, so that the tree seems to be past its best. It still looks well, and has reached the respectable girth of seven feet three inches.

The range in the first decade, ·75 to 1·10, was slight, but the decline in the second has raised it to ·45 to 1·10 in the whole period of twenty years.

JUGLANS REGIA.

| No. in List. | Annual Rate, 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 12 | ·13 | ·05 | ·00 | ·15 | ·00 | ·50 | ·25 | ·25 | ·15 | ·15 | ·10 | 1·40 | ·14 | 136·50 |

As the Walnut is rare in the Edinburgh district, it is somewhat surprising to see so large a specimen in a situation so little favourable to tree longevity as the Arboretum, and where it has been so much exposed to the west winds. It has a short stem, eleven feet four inches in girth at the narrowest, a foot above ground, which has only increased an inch or two in twenty years. The two chief limbs girth upwards of eight and five feet. The only annual measurements kept up were on the latter, and it has increased, very irregularly, only two and a half inches in twenty years. Very probably the girth-increase was permanently checked by the low temperatures of 1880, as in the previous year it increased ·40 and in 1878 ·50, almost as much as in the following eighteen years. In some years it produces an abundance of fruit, which, however, never reaches anything like maturity. The

soil of the Garden seems rather favourable to the walnut, as a very handsome specimen, four feet nine inches in girth, recently transplanted, promises to do well.

## SALIX SP.

| No. in List. | Annual Rate, 1st Decade. | Annual Increments | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 19 | ... | ·90 | 1·80 | 1·65 | 1·65 | 2·40 | 2·80 | 2·65 | 4·00 | 3·00 | 2·40 | 23·25 | 2·32 | 26·25 |

This Willow, on the South side of the pond, but on dry ground, was measured in its infancy at three feet above ground, the point being raised to five feet when practicable. It was at first only an inch and a half in girth, and is now about two feet at the five-feet mark, having grown twenty-three inches in ten years, at the rate of 1·68 in the first quinquennium, and 2·97, or all but three inches, in the second. The increases of four inches in 1895 and three in 1896 are quite unequalled in other species in all my twenty years' observations.

## POPULUS FASTIGIATA.

| No. in List. | Annual Rate, 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 76 | ... | ·75 | 1·75 | 1·35 | ·75 | 1·45 | *·00* | *·50* | ·95 | dying | ... | 7·00 | 1·17 | 15·05 |
| 87 | ... | ·80 | 1·35 | 1·00 | ·45 | ·80 | dead | ... | ... | ... | ... | 4·40 | ·88 | 12·65 |
| 9 | ... | ... | ... | ... | ... | 1·25 | 1·35 | 1·05 | 1·30 | *·80* | *·65* | 4·95 | 1·24 | 15·10 |

Three of this species were under observation in the second decade, but the careers of Nos. 76 and 87 have been ended by transplantation followed by death, and that of No. 9 by transplantation threatening death. The average rate in the few available years was 1·18 in No. 76, and 1·24 in No. 9, and if we deduct the years 1891 and 1892 from No. 87, when it was evidently failing, its rate would be 1·05, or not much less than in the others.

## ALNUS GLUTINOSA.

| No. in List. | Annual Rate, 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 88 | ... | ·85 | 1·20 | ·60 | ·70 | ·65 | ·70 | ·50 | ·75 | *·10* | *·05* | 5·95 | ·74 | 14·20 |
| 7 | ... | ... | ... | ... | ... | ·85 | ·80 | ·60 | ·75 | *·30* | *·15* | 3·00 | ·75 | 11·85 |

The results in this species are also not very satisfactory. No. 88 at first looked well, and in 1889 had an increase of 1·20, but fell off in appearance thereafter, with an increase never rising above ·75 in the six next years. It was then transplanted. No. 7 has never looked vigorous. The annual averages of the two, ·74 and ·75, are almost identical, but cannot be regarded as representative of normal growth.

## BETULA ALBA.

| No. in List. | Annual Rate, 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 1 | ·07 | ·05 | ·00 | ·20 | ·05 | ·05 | ·10 | ·10 | ·05 | ·15 | ·00 | 0·75 | ·07 | 56·80 |
| 78 | ... | ·80 | 1·35 | 1·10 | ·95 | 1·45 | 1·30 | 1·25 | trans | pl'd & | died | 8·20 | 1·17 | 19·55 |
| 82 | ... | ·70 | ·90 | 1·10 | ·80 | 1·40 | cut | down | ... | ... | ... | 4·90 | ·98 | 26·65 |
| 17 | ... | ... | ... | ... | ... | 1·70 | 1·80 | 1·60 | 1·35 | *·50* | *·30* | 6·45 | 1·61 | 20·20 |

The only Birch measured in the first decade, No. 1, was a transplant from the former Garden in 1822, and was for long a chief ornament of the present one. Previously to 1878 it had been measured for three years, and had an annual rate of ·41, but in that year it dropped to ·25, and possibly the tree was past its prime. Then came the three winters so disastrous to girth-increase in general, when many twigs died, the girth-increase almost ceased, and at the end of the decade not half of the long weeping branches remained. In the second decade there was no rally of girth-increase, which in twenty years has only amounted to an inch and a half, but there has been little further degeneration in appearance, and the tree, now nearly five feet in

girth, still retains something of its original beauty. The cause of its falling off has been ascertained by recent borings to be a fungoid disease in the stem. A Birch of the same size at Craigiehall in the first decade grew for eight years at the annual rate of nearly half an inch.

The two younger Birches, Nos. 78, 82, yielded rates of 1·17 and ·98 for seven and five years respectively, the ranges being ·80 to 1·45 and ·70 to 1·40. But No. 17, about the same age, showed the much better average of 1·61 for the four available years of its career.

## CARPINUS BETULUS.

| No. in List. | Annual Rate, 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 33 | ·41 | ·25 | ·40 | ·45 | ·30 | ·45 | ·55 | ·35 | ·30 | ·50 | ·25 | 3·80 | ·38 | 52·40 |
| 81 | ... | ·80 | 1·00 | ·65 | ·55 | ·45 | *·00* | *·35* | ·65 | ·85 | ·70 | 5·65 | ·71 | 11·90 |
| 86 | ... | ·40 | ·70 | ·60 | ·70 | ·75 | ·80 | ·65 | 1·00 | *·15* | *·00* | 5·60 | ·70 | 11·30 |

No. 33, a tall, erect, and handsome tree in 1878, above three and a half feet in girth, grew at the rate of ·41 in the first decade and in the second at the somewhat less rate of ·38, always rather falling off in condition. It is now four feet four inches in girth. The annual rate of the two much younger Hornbeams, Nos. 81, 86, selected for the second decade in the South border of the Arboretum, was ·70 and ·71. Their growth was erratic, as shown by the range, which in the former was ·45 to 1·00 and in the latter ·40 to 1·00.

## LIRIODENDRON TULIPIFERA.

| No. in List. | Annual Rate, 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 6 | ·60 | ·35 | ·40 | ·80 | ·50 | ·65 | ·40 | ·75 | ·35 | ·40 | ·25 | 4·85 | ·48 | 86·55 |

This short-stemmed but handsome spreading tree seems to have been a quick grower up to a girth of about six feet, at the

narrowest part, four feet two inches above ground, as Sir Robert Christison ascertained its rate to have been 1·20 for the three years before the first decade, and in the first year of that decade it grew 1·00. It then encountered the three hard winters, in the two first of which the rate fell to ·40 and ·30, and it never afterwards rallied to above ·80; the average rate in the first decade being ·60 and in the second ·48. Notwithstanding this progressive decrease, the tree is still handsome and healthy looking, with a girth of above seven feet at four feet above ground, and nearly ten feet at the base.

## ROBINIA PSEUDACACIA.

| No. in List. | Annual Rate, 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 14 | ... | ... | ... | ... | ... | ·60 | ·75 | ·85 | 1·40 | 1·05 | ·95 | 5·60 | ·93 | 11·90 |

This very young tree is thriving well in the North border of the Arboretum. It was but slightly pruned in 1895, so I have included the two following years' results. The rate, compared with other infant trees, seems good, as it is barely a foot in girth, and has increased nearly at the rate of an inch a year for six years. The growth was progressive, from ·60 to 1·40 for four years, but has declined to ·95 in the next two years.

## CRATÆGUS OXYACANTHA.

| No. in List. | Annual Rate, 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 16 | ·55 | ·60 | ·65 | ·65 | ·45 | ·50 | ·65 | ·35 | *·05* | *·10* | *·05* | 3·85 | ·55 | 47·55 |
| 19 | ... | 1·05 | 1·65 | ·95 | 1·00 | 1·20 | ·45 | ·50 | ·85 | *·10* | *·20* | 7·65 | ·96 | 10·40 |
| 11 | ... | ... | ... | ... | ... | 1·00 | 1·10 | ·85 | 1·10 | *·20* | *·25* | 4·05 | 1·01 | 14·45 |

The handsome Hawthorn, No. 16, at the East walk of the Garden, grew at the rate of a little above half an inch in the first decade, and attained a girth of above three and a half feet.

In the first seven years of the second decade its rate continued precisely the same ; but in 1895 its roots were cut round about to prepare it for transplantation. It then almost ceased to grow till 1899, when it was transplanted to the Arboretum. It now girths all but four feet, and promises to do well in its new quarters.

The rates of the two quite young trees, Nos. 19 and 11, in the second decade, for eight and four years respectively, have been ·96 and 1·01, or about one inch each. The increase in No. 19, the one observed for the longest period, has been erratic, as proved by the extreme range of ·45 to 1·20 in eight years.

## CYTISUS LABURNUM.

| No. in List. | Annual Rate, 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 21 | ... | ·75 | 1·00 | ·85 | ·90 | ·70 | 1·05 | ·75 | ·15 | ·35 | ·85 | 6·85 | ·86 | 13·30 |
| 1 | ... | ... | ... | ... | ... | ·85 | ·55 | ·85 | ·45 | ·30 | ·35 | 2·70 | ·67 | 11·80 |

The results in these young Laburnums, still only about a foot in girth, have been ·86 and ·67, or an average of about three-quarters of an inch. The range in the one longest tested, No. 21, has been moderate, ·75 to 1·05.

## PYRUS COMMUNIS.

| No. in List. | Annual Rate, 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 8 | ... | ... | ... | ... | ... | ·95 | ·90 | ·65 | ·70 | ·25 | ·10 | 3·20 | ·80 | 14·70 |

The rate of this young Pear tree, in the West border of the Arboretum, was ·80 for four years, when it was healthy-looking, but the increase almost ceased from excessive pruning, which threatens the life of the tree.

## PYRUS AUCUPARIA.

| No. in List. | Annual Rate, 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 77 | ... | ·80 | ·40 | ·75 | ·55 | ·75 | ·60 | ·55 | *·5* | *·35* | ·70 | 5·10 | ·64 | 12·45 |
| 79 | ... | ·75 | 1·05 | 1·10 | ·90 | *·20* | *·45* | ·80 | ·80 | ·90 | ·85 | 7·15 | ·89 | 14·70 |
| 13 | ... | ... | ... | ... | ... | ·85 | ·90 | ·75 | ·70 | *·10* | *·00* | 3·20 | ·80 | 16·50 |

The rate of No. 77 was only ·60, kept down perhaps by the very sandy soil where it grew, in the South border of the Arboretum, as No. 79, in the East border, had the considerably better rate of ·89. It was somewhat less, only ·80, in No. 13, favourably situated in the West border, but it has been under observation for only four available years. The ranges of all three, ·40 to ·70, ·75 to 1·10, and ·70 to ·90, have been moderate.

## PRUNUS PADUS.

| No. in List. | Annual Rate, 1st Decade. | Annual Increments. | | | | | | | | | | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | | | |
| 18 | ... | ·65 | ·90 | ·80 | ·70 | ·70 | 1·00 | ·60 | *·00* | ·75 | ·70 | 6·80 | ·76 | 11·20 |
| 22 | ... | 1·20 | 1·45 | 1·35 | 1·35 | *·15* | *·80* | 1·05 | 1·55 | 1·35 | 1·10 | 10·40 | 1·30 | 17·20 |
| 5 | ... | ... | ... | ... | ... | 2·00 | 1·90 | 1·60 | 1·70 | *1·10* | *1·00* | 7·20 | 1·80 | 21·65 |

These two trees, growing apparently under much the same conditions in the South border of the Arboretum, before being transplanted, have fared very differently, the rate of No. 18 being only ·76, while that of No. 22 was 1·30. The range in both was comparatively small, ·60 to 1·00 and 1·05 to 1·55. But No. 5, South of the Arboretum Lodge, proved greatly superior to these, with an average of 1·80 for four years, and the small range of 1·60 to 2·00. It is thus one of the few trees of any species that has grown as much as two inches in a single year.

## B. Annual Rate and Range of Girth-increase in Deciduous Trees at Different Ages.

The rate of girth-increase in trees must evidently be affected by various conditions of locality, such as soil, shelter, crowding or the reverse, the effects of which cannot always be easily eliminated. But another condition of no little influence is age, for there is a natural rise in the annual increase from infancy through youth, and a subsequent decline, the limits of which in the different species have not been, perhaps cannot be, determined. To get rid in some degree of this last cause, I have divided my trees in Tables I. to V. under five categories, according to their size. Usually only the quickest growers have been given, as being more likely to be representative of the normal characteristics of the species than such as proved comparative failures. Some have been under observation for a period sufficiently long to appear in more than one of the categories.

Leaving the Tables mainly to tell their own tale, attention may be directed to a few of the chief points in each of the categories.

ANNUAL RATE.

## ANNUAL RATE AND RANGE OF INCREASE IN GIRTH IN DECIDUOUS TREES.

TABLE I.—Under 15 inches in Girth at the end of the Observations.

| No. in List. | Species. | Girth at last Observation. | Annual Rate. | Least Increase in a Year. | Greatest Increase in a Year. | Number of Years. |
|---|---|---|---|---|---|---|
| 96 | Salix ... ... ... ... | 12·70 | 2·06 | 1·65 | 2·80 | five. |
| 94 | Ulmus montana ... ... | 15·00 | 1·45 | 1·15 | 1·75 | three. |
| 22 | Prunus Padus ... ... | 13·15 | 1·30 | 1·15 | 1·45 | five. |
| 98 | Fagus sylvatica ... ... | 14·55 | 1·29 | 1·00 | 1·55 | five. |
| 16 | Acer Pseudoplatanus ... | 15· | 1·27 | 1·20 | 1·40 | three. |
| 9 | Populus fastigiata ... ... | 13·65 | 1·24 | 1·05 | 1·35 | four. |
| 76 | Do. ... ... | 14·15 | 1·17 | ·75 | 1·75 | five. |
| 61 | Quercus rubra ... ... | 10·95 | 1·18 | ·90 | 1·50 | five. |
| 23 | Fraxinus excelsior ... ... | 14·50 | 1·07 | ·85 | 1·40 | five. |
| 78 | Betula alba ... ... ... | 14·50 | 1·05 | ·95 | 1·35 | five. |
| 11 | Cratægus Oxyacantha ... | 14·00 | 1·01 | ·85 | 1·10 | four. |
| 19 | Do. ... | 10·10 | ·96 | ·45 | 1·65 | eight. |
| 14 | Robinia Pseudacacia ... | 11·90 | ·93 | ·60 | 1·40 | six. |
| 70 | Quercus robur ... ... | 13·90 | ·89 | ·50 | 1·20 | nine. |
| 79 | Pyrus Aucuparia ... ... | 14·05 | ·89 | ·75 | 1·10 | eight. |
| 21 | Cytisus Laburnum ... ... | 13·30 | ·86 | ·70 | 1·05 | eight. |
| 8 | Pyrus communis ... ... | 14·35 | ·80 | ·65 | ·95 | four. |
| 69 | Tilia europœa ... ... ... | 12·60 | ·77 | ·60 | 1·00 | nine. |
| 7 | Alnus glutinosa ... ... | 11·40 | ·75 | ·60 | ·85 | four. |
| 88 | Do. ... ... | 14·05 | ·74 | ·50 | 1·20 | eight. |
| 81 | Carpinus Betulus ... ... | 11·90 | ·71 | ·45 | 1·00 | eight. |
| 86 | Do. ... ... | 11·15 | ·70 | ·40 | 1·00 | eight. |
| 16 | Quercus Ilex ... ... ... | 8·60 | ·63 | ·45 | ·85 | seven. |

TABLE II.—Between 15 inches and 2 feet in Girth.

| No. in List. | Species. | Girth at last Observation. | Annual Rate. | Least Increase in a Year. | Greatest Increase in a Year. | Number of Years. |
|---|---|---|---|---|---|---|
| 96 | Salix ... ... ... ... | 23·85 | 3·21 | 2·65 | 4·00 | three. |
| 5 | Prunus Padus ... ... ... | 21·65 | 1·80 | 1·60 | 2·00 | four. |
| 93 | Ulmus montana ... ... | 19·55 | 1·70 | 1·50 | 1·80 | four. |
| 17 | Betula alba ... ... ... | 19·40 | 1·61 | 1·35 | 1·80 | four. |
| 54 | Quercus conferta ... ... | 24·50 | 1·61 | 1·10 | 1·90 | five. |
| 55 | Do. ... ... | 21·40 | 1·58 | 1·10 | 1·80 | five. |
| 20 | Fagus sylvatica ... ... | 19·80 | 1·45 | 1·20 | 1·70 | three. |
| 74 | Acer Pseudoplatanus ... | 18·80 | 1·47 | 1·40 | 1·55 | five. |
| 3 | Tilia europœa ... ... ... | 18·80 | 1·24 | ·90 | 1·45 | four. |
| 2 | Fraxinus excelsior ... ... | 17·15 | 1·21 | 1·10 | 1·30 | four. |
| 4 | Œsculus Hippocastanum ... | 17·65 | 1·21 | 1·05 | 1·40 | four. |
| 12 | Acer campestris ... ... | 19·75 | 1·20 | ·85 | 1·60 | six. |

TABLE III.—Between 2½ feet and about 5 feet in Girth.

| No. in List. | Species. | Girth at last Observation. | Annual Rate. | Least Increase in a Year. | Greatest Increase in a Year. | Number of Years. |
|---|---|---|---|---|---|---|
| 54 | Quercus conferta ... ... | ·36 | 1·86 | 1·30 | 2·05 | six. |
| 40 | Do. ... ... | ·36 | 1·69 | 1·05 | 1·80 | six. |
| 55 | Do. ... ... | ·36 | 1·60 | 1·30 | 2·10 | six. |
| 93 | Ulmus montana ... ... | ·31 | 1·71 | 1·35 | 2·05 | three. |
| 43 | Quercus Cerris ... ... | ·53 | ·57 | ·35 | ·65 | twenty. |
| 16 | Cratægus Oxyacantha ... | ·48 | ·55 | ·10 | ·80 | twenty. |
| 33 | Carpinus Betulus ... ... | ·52 | ·40 | ·10 | ·55 | twenty. |
| 18 | Tilia europœa ... ... | ·46 | ·35 | ·15 | ·70 | ten. |
| 28 | Acer Pseudoplatanus ... | ·62 | ·35 | ·15 | ·50 | ten. |
| 9 | Œsculus Hippocastanum ... | ·52 | ·32 | ·05 | ·75 | ten. |

TABLE IV.—Old Trees, from about 6 feet to 7½ feet in Girth.
Decade 1878-87.

| No. in List. | Species. | Girth at last Observation. | Annual Rate. | Least Increase in a Year. | Greatest Increase in a Year. | Number of Years. |
|---|---|---|---|---|---|---|
| 7 | Fagus sylvatica ... ... | ·82 | 1·03 | ·65 | 1·20 | ten. |
| 8 | Do. ... ... | ·70 | ·99 | ·90 | 1·20 | ten. |
| 4 | Castanea vesca ... ... | ·80 | ·94 | ·75 | 1·10 | ten. |
| 6 | Liriodendron tulipiferum ... | ·82 | ·60 | ·30 | 1·00 | ten. |
| 3 | Fraxinus Ornus ... ... | ·80 | ·41 | ·20 | ·75 | ten. |
| 2 | Tilia europœa ... ... ... | ·78 | ·30 | ·00 | ·65 | ten. |

TABLE V.—Decade 1888-97.

| No. in List. | Species. | Girth at last Observation. | Annual Rate. | Least Increase in a Year. | Greatest Increase in a Year. | Number of Years. |
|---|---|---|---|---|---|---|
| 7 | Fagus sylvatica ... ... | ·90 | ·85 | ·60 | 1·20 | ten. |
| 8 | Do. ... ... | ·80 | ·92 | ·80 | 1·10 | ten. |
| 4 | Castanea vesca ... ... | ·87 | ·69 | ·40 | 1·00 | ten. |
| 6 | Liriodendron tulipiferum ... | ·86 | ·48 | ·25 | ·80 | ten. |
| 2 | Tilia europœa .. ... ... | ·81 | ·27 | ·00 | ·50 | ten. |

TABLE VI.—Rates of Old Trees at Craigiehall, Cramond, for comparison.

| No. in List. | Species. | Girth at last Observation. | Annual Rate. | Least Increase in a Year. | Greatest Increase in a Year. | Number of Years. |
|---|---|---|---|---|---|---|
| 10 | Quercus Cerris ... ... | ·80 | ·92 | ·70 | 1·25 | eight. |
| 20 | Fagus sylvatica ... ... | 1·43 | ·81 | ·60 | ·95 | eight. |
| 16 | Quercus robur .. ... | 1·27 | ·69 | ·45 | 1·00 | eight. |
| 5 | Betula alba ... ... ... | ·60 | ·45 | ·40 | ·55 | eight. |
| 6 | Fraxinus excelsior ... ... | 1·44 | ·37 | ·25 | ·70 | ten. |
| 7 | Acer Pseudoplatanus ... | 1·30 | ·40 | ·20 | ·55 | ten. |

## I. TREES UNDER 15 INCHES IN GIRTH.

*Annual rate.*—These infant trees have been under observation for from three to eight years. Fully one-half of the twenty-three trees and of the nineteen species had an annual rate of an inch or upwards, the Willow being *facile princeps* with a rate of two inches for five years, when it grew in girth from three to thirteen inches. The Wych Elm follows with

nearly an inch and a half for three years; then come the Cherry, Beech, Sycamore, and Poplar with about an inch and a quarter, and the American Oak, Ash, Birch, and Hawthorn with about an inch. At the other end of the scale are Alder and Hornbeam with three-fourths of an inch, Robinia, British Oak, Rowan, Laburnum, Pear, and Lime being slightly better than that.

*Annual range.*—Naturally this tends to be greatest in the trees that were longest under observation; but even confining ourselves to the seventeen which had from five to nine years' records the range is not great. In ten the maximum was less, sometimes much less, than double the minimum; in six it was only rather more than double; and in only one was it extreme, being three and a half times greater than the minimum. This was the Hawthorn, No. 19, a very infantile specimen, and in the slightly older No. 11 the range was quite slight.

*Maximum single year's increase.*—Only three of the twenty-three trees failed to attain one inch of increase in one or more years; these were the Pear, with 95; Alder, No. 7, with 85; and Evergreen Oak, with 85. But another Alder, No. 88, attained 1·20. The highest results were—Willow 2·80, Wych Elm 1·75, Poplar 1·75, Hawthorn 1·65.

## II. TREES BETWEEN 15 INCHES AND TWO FEET IN GIRTH.

*Annual rate.*—Of the twelve trees, belonging to eleven species, admissible to this category, eight have already figured in the infantile period. The Willow reappears with the very high rate of 3·21 for three years. The Cherry now takes second place with 1·80, and Wych Elm follows with 1·70; but the Birch, and the two new comers of *Quercus conferta*, are also above an inch and a half, and *Acer campestris*, at the bottom of the list, averages, along with Lime, Ash, and Horse Chestnut, about an inch and a quarter.

*Annual range.*—This is much less than in the infantile period. In no tree is the maximum double the minimum; generally it is considerably less, and only in *Acer campestris* does it come perilously near as much.

*Maximum single year's increase.*—Willow again far and away heads the list with no less than four inches in a single year. Cherry is the only other that attains even two inches, although

one Hungary Oak comes near it with 1·90; the other Hungary Oak, with the Wych Elm and Birch, attain fully an inch and three-quarters, and the Ash, at the bottom of the list, reached an inch and a quarter.

## III. TREES BETWEEN TWO AND A HALF AND FIVE FEET IN GIRTH.

*Annual rate.*— Few of the species and none of the actual trees of the first or Infant Table are to be found in this category, which includes ten trees, three being Hungary Oaks. They head the list, one of them with 1·86, but it is fair to state that they are younger than most of the others; the Wych Elm is well up with 1·71; but the next best, a Turkey Oak, has only ·57, and the others dwindle down to ·32, the rate for ten years of a Horse Chestnut.

*Annual range.*—This was moderate in the three Hungary Oaks, the Wych Elm, and Turkey Oak, the maximum being less than double the minimum; but it was very great in Hawthorn, Hornbeam, Lime, Sycamore, and Horse Chestnut, the proportion being as ·50 to ·15 in Sycamore, the best of them, and as ·05 to ·75 in Horse Chestnut, the worst; a proof, I think, that these trees, healthy though they look, had passed their prime of growing power when only from four to five feet in girth.

*Maximum single year's increase.*—The three specimens of Hungary Oak are conspicuous with 2·10, 2·05, and 1·80, and the Wych Elm also mounted a trifle above two inches; but Hawthorn, Lime, and Horse Chestnut do not attain more than about three-quarters of an inch, Turkey Oak somewhat less, Sycamore and Hornbeam only half an inch.

## IV. TREES FROM ABOUT SIX TO SEVEN AND A HALF FEET IN GIRTH.

Our list is now reduced to six trees, none of which appeared in the former categories. As they were observed for twenty years they may conveniently be divided into two decades.

*Annual rate.*—The two Beeches, which attained respectively nearly seven and nearly six feet in girth in the first decade, and seven feet and a half and six feet and a half in the second, are at the head, with a rate of 1·03 and ·99 in the decade 1878–87,

and ·88 and ·92 in the decade 1888–97. This shows a considerable falling off in the second period, although the trees seem as vigorous and healthy as ever. The Spanish Chestnut, with ·94 and ·69, shows the same tendency, as do the Tulip tree, with ·60 and ·48, and in a less degree the remarkably handsome Lime, nearly seven feet in girth, with ·30 and ·27. As to the flowering Ash, although its rate was ·40 in the first decade, it almost ceased to increase in the second, while showing little degeneracy in its general aspect.

*Annual range.*—This was slight in the Beech No. 8 and the Spanish Chestnut, at least in its first decade; moderate, the maximum being somewhat less than double the minimum, in Beech No. 7; large in the Tulip tree and flowering Ash; and extreme in the Lime, ·00 to ·65.

*Maximum single year's increase.*—Beech No. 7 attained 1·20 in both decades, and No. 8 the same in the first decade and 1·10 in the second; Spanish Chestnut reached 1·10 in the first and 1·00 in the second; Tulip tree 1·00 in the first and ·80 in the second; and Lime ·65 in the first and ·50 in the second.

### C. Comparison with Trees in the Neighbourhood of Edinburgh.

The rates, particularly of the older trees in the Botanic Garden, by no means represent the capacity for increase in trees of the same or even of greater size in the Edinburgh district, when more favourably situated as to soil.

Even the handsome Beeches Nos. 7, 8, with a rate of ·85 and ·92, when six and a half and seven and a half feet in girth respectively, were nearly equalled by a specimen twelve feet in girth, with a rate of ·81 for eight years, at Craigiehall; and the wonderful tree at Newbattle, nineteen feet in girth, shows what is possible at so great a size, by having increased at the annual rate of about half an inch for fifteen years.

The largest British Oak in the Garden is much of a wreck, although only eight feet in girth, and has been increasing for twenty years at about the annual rate of only a quarter of an inch; but one at Craigiehall kept up a rate of nearly three-quarters of an inch for eight years, although at the considerably greater girth of ten and a half feet.

A fine Turkey Oak in the Garden, four and a half feet in

girth, had a rate of ·57, while one at Craigiehall, six and a half feet in girth, gave a rate of ·92 for eight years, and a very vigorous specimen at Cramond, nearly thirteen feet in girth when measured in 1878, must certainly have been a rapid grower.

The handsome Sycamore, No. 28, five feet in girth, with the unaccountably low rate of ·35, is not much above the ·22 of the largest Sycamore, eleven feet in girth, in the Garden; and a Craigiehall tree, nearly as large, excelled it with a rate of ·40 for ten years.

The finest Birch in the Garden ceased to increase when a few inches short of five feet in girth, while a slightly larger specimen at Craigiehall continued to grow at the rate of nearly half an inch for eight years.

### D. Aggregate Annual Results.

The results in the aggregate are chiefly interesting as showing, in the first place, the effects upon girth-increase of good or bad seasons; and, secondly, any tendency there may be towards alteration in the rate from increasing age in the trees. This inquiry must be confined to the group of adult and aged trees, as in them alone has the period of observation, amounting in most of them to twenty years, been sufficient to yield reliable results. As the two kinds of results just specified are concurrent it will be easier to study them together than separately, and it will be advantageous to take first the species which seem to be still growing with undiminished vigour, as far as external appearance goes, and subsequently those that may be suspected of having decidedly passed their prime. The first set includes Beech, Hungary Oak, and Turkey Oak, of each of which from two to four specimens were under observation. These will be dealt with separately. The second set contains nine species, mostly illustrated by only one specimen, and may be taken in mass.

The first decade of observations, 1878–1887, was remarkable for three successive most unfavourable seasons, 1879, 1880, and 1881. In all three the winters were marked by exceedingly low temperatures, and in 1879 the growing months were remarkably cold and sunless. Fortunately the measurements in most of the species began in the previous year, and thus we can appreciate the extraordinary immediate loss in the aggregate girth-increase

and the prolonged effects on some of the trees, all of which is fully detailed in former papers.* Suffice it to say here that in 1880, the worst year for the deciduous trees, their aggregate girth-increase was only half what it was in 1878, and that, while the Deciduous group reached their minimum of increase in 1880, the second of the three severe seasons, rallying very decidedly in 1881, the Pinaceæ continued to fall off in that season and did not rally till 1882.

The second decade shows no such startling results, and the other seasonal fluctuations, considerable though they be, are probably only such as may be ordinarily expected in a climate so variable as ours ; but they are interesting as showing that the species were not all implicated in the same seasons of depression. The effects of increasing age seem to be pretty clearly indicated also.

## FAGUS SYLVATICA.

AGGREGATE GIRTH-INCREASE IN FOUR BEECHES FOR TWENTY YEARS.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| First Decade, .. .. | 1878. | 1879. | 1880. | 1881. | 1882. | 1883. | 1884. | 1885. | 1886. | 1887. |
| Increase, .. .. | 3·60 | 2·85 | 1·95 | 2·75 | 3·35 | 2·90 | 3·45 | 2·85 | 3·10 | 2·60 |
| Second Decade, .. .. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. |
| Increase, .. .. | 2·25 | 2·35 | 2·35 | 2·30 | 2·80 | 2·50 | 2·75 | 2·05 | 2·65 | 2·25 |

These four Beeches girthed, in round numbers, five and a half, six and a half, seven, and seven and a half feet in 1897, and showed no outward sign of diminished vigour. The Table shows, however, that they never quite regained the standard of 3·60 in 1878, the year preceding the three severe seasons, although twice, in 1882 and 1884, they very nearly did so. Their minimum, 1·95, occurred in the second bad season, and severe as the fall may seem, it was less than in any of the other deciduous species. The rally to 2·75 in 1881 and to 3·35 in 1882 was so complete that evidently no permanent injury had been done, and the subsequent gradual though fluctuating

* "The Influence of the Unfavourable Season of 1879 on the Growth of Trees." By Sir R. Christison, Bart., Tr. Bot. Soc. Ed., 1880.

"The Growth of Wood in 1880." By Sir R. Christison. *Op. cit.*, 1881.

"The Depression in Girth Increase of Trees in 1879, 1880, 1881." Dr. D, Christison. *Op. cit.*, 1888-89, p.

decrease in girth-increase is probably due to increasing age. In the second decade the maximum, 2·80, compares unfavourably with the 3·60 before the bad years, and 3·45 after them, of the first decade. The range in the first decade, 1·95 to 3·60, is great owing to the severe winters; in the second it is remarkably small, 2·05 to 2·80. That the Beeches were subject to minor depressions, in common with other species, in 1883, 1885, 1887, and 1895 is evident, but I have not been able to inquire into their causes.

## QUERCUS CERRIS.

AGGREGATE GIRTH-INCREASE IN TWO TURKEY OAKS FOR EIGHTEEN YEARS.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1878. | 1879. | 1880. | 1881. | 1882. | 1883. | 1884 | 1885. | 1886. | 1887. |
| First Decade, .. .. | .. | .. | 1·05 | 1·85 | 1·55 | 1·45 | 1·55 | 1·50 | 1·45 | 1·45 |
| | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. |
| Second Decade, .. .. | 1·20 | ·75 | 1·35 | 1·10 | 1·40 | 1·50 | 1·30 | 1·05 | 1·50 | 1·15 |

Unfortunately these Turkey Oaks only came under observation in the third year of the first decade, but the decided rally from 1·05 in that year to 1·85 in the next indicates that they shared in the general depression of the time. It is somewhat remarkable that they never again approached the standard of 1881 nearer than 1·55. The only other startling event in their career was the great fall in 1889 to the minimum, ·75, due apparently to some cause specially affecting the species, as few others showed any sign of depression then. On the whole, there has been a falling off in the amount of girth-increase with time, but not to a marked degree.

The range was 1·05 to 1·85 in the first decade, and ·75 to 1·50 in the second.

## QUERCUS CONFERTA.

AGGREGATE GIRTH-INCREASE OF THREE HUNGARY OAKS FOR FOURTEEN YEARS.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1878. | 1879. | 1880. | 1881. | 1882. | 1883. | 1884. | 1885. | 1886. | 1887. |
| .. | .. | 3·60 | 5·15 | 5·25 | 5·40 | 5·05 | 4·8 | 4·65 | 5 30 |
| 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. |
| 3·65 | 4·50 | 5·05 | 4·05 | 5·15 | 6·00 | .. | .. | .. | .. |

The Hungary Oaks only came under observation in the same year as their Turkish cousins, but, like them, a rise from 3·60 in 1880 to 5·15 in 1881 indicates a marked depression during the severe winters of 1879 and 1880. They then went on steadily till 1888, a year of pretty general depression, when they descended nearly to the level of 1880. Another severe fall, to 4·05, occurred in the generally unfavourable year of 1891, but an immediate recovery took place, and in 1893 they reached their maximum of 6·00. A severe pruning, to promote upward growth, has been successful in that object, but has reduced their girth-increase to a mere trifle for six years. Previously it is plain that, on the whole, their girth-increase had been increasing, due probably to their being adolescents and not adults.

The range in the first decade was from 3·60 to 5·40, and in the second from 3·65 to 6·00.

[AGGREGATE.

AGGREGATE. INCREASE IN GIRTH FOR TWENTY YEARS OF NINE OTHER SPECIES OF INFERIOR OR DECLINING VIGOUR.

| First Decade. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1878. | 1879. | 1880. | 1881. | 1882. | 1883. | 1884. | 1885. | 1886. | 1887. |
| Tilia europœa (2) .. .. | 1·20 | ·55 | ·15 | ·90 | ·95 | ·55 | ·70 | ·65 | ·50 | ·40 |
| Castanea vesca .. .. | 1·10 | ·90 | ·85 | 1·10 | ·90 | 1·00 | 1·00 | ·85 | 1·00 | ·75 |
| Liriodendron tulipifera .. | 1·00 | ·40 | ·30 | ·65 | ·60 | ·45 | ·65 | ·55 | ·70 | ·65 |
| Acer Pseudoplatanus .. | ·50 | ·20 | ·15 | ·30 | ·40 | ·45 | ·55 | ·40 | ·35 | ·20 |
| Œsculus Hippocastanum | ·75 | ·50 | ·35 | ·70 | ·10 | ·30 | ·20 | ·05 | ·20 | ·20 |
| Carpinus Betula .. .. | ·40 | ·35 | ·10 | ·55 | ·5 | ·45 | ·55 | ·40 | ·30 | ·50 |
| Quercus rubra .. .. | ·50 | ·40 | ·30 | ·50 | ·40 | ·40 | ·45 | ·55 | ·45 | ·55 |
| Juglans regia .. .. | ·50 | ·40 | ·00 | ·00 | ·10 | ·10 | ·15 | ·00 | ·15 | ·15 |
| Betula alba .. .. .. | ·25 | ·05 | ·05 | ·10 | ·10 | 00 | ·10 | ·00 | ·10 | ·00 |
| Total .. .. .. | 6·20 | 3·75 | 2·25 | 4·80 | 4·15 | 3·70 | 4·35 | 3·45 | 3·80 | 3·40 |

| Second Decade. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. |
| Tilia europœa .. .. | ·30 | ·65 | ·95 | ·40 | ·65 | 1·05 | ·80 | ·10 | ·70 | ·35 |
| Castanea vesca .. .. | ·60 | ·75 | 1·00 | ·60 | ·90 | ·90 | ·40 | ·80 | ·45 | ·8 |
| Liriodendron tulipifera .. | ·35 | ·40 | ·80 | ·50 | ·65 | ·40 | ·75 | ·35 | ·40 | ·25 |
| Acer Pseudoplatanus .. | ·20 | ·20 | ·30 | ·10 | ·35 | ·25 | ·15 | ·15 | ·35 | ·15 |
| Œsculus Hippocastanum | ·35 | ·10 | ·05 | ·00 | ·25 | ·10 | ·25 | ·25 | ·30 | ·00 |
| Carpinus Betula .. .. | ·25 | ·40 | ·45 | ·30 | ·45 | ·55 | ·35 | ·30 | ·50 | ·25 |
| Quercus rubra .. .. | ·40 | ·30 | ·50 | ·35 | ·45 | ·40 | ·55 | ·40 | ·35 | ·25 |
| Juglans regia .. .. | ·05 | ·00 | ·15 | ·00 | ·30 | ·25 | ·25 | ·15 | ·15 | ·10 |
| Betula alba .. .. .. | ·05 | ·00 | ·20 | ·05 | ·05 | ·10 | ·10 | ·05 | ·15 | ·00 |
| Total . .. .. | 2·55 | 2·75 | 4·45 | 2·30 | 4·05 | 4·00 | 3·60 | 2·55 | 3·35 | 2·20 |

The progressive though fluctuating degeneracy in this group is very marked. From the standard of 6·20 in 1878 the fall in 1880, the second severe season, was to 2·25, and the rally in 1881 was only to 4·80, an amount which they never again quite reached. Their average for the last five years was little above 3·00, or one-half the standard of 1878. It is probable, therefore,

that the severe seasons of 1879 and 1880 produced, besides an immediate severe depression, a permanent effect, by accelerating, or it may be in some cases inducing, the falling off in girth increase to be looked for in trees either beyond their prime or in weak health ; and this took place in the majority without any apparent degeneracy in the foliage. In the two Limes and the Sycamore it has always been fine, and the same may be said, in a somewhat less degree, of the Spanish Chestnut, Tulip Tree, and Hornbeam. The conduct of the Horse Chestnut was peculiar. It probably rallied completely in 1881 from the previous severe seasons, but in 1882 fell a victim to some disease that withered the foliage early in summer of nearly all the Sycamores near Edinburgh, and, although subsequently the foliage was always healthy and dense, the girth-increase for fifteen years has been very slight, and in some seasons there has been none at all. Permanent injury to girth-increase, if it existed at all, is least traceable in the Hornbeam and American Oak. In the Walnut and Birch the degeneracy both in appearance and girth-increase is distinct.

### E. Variety in the Incidence of Years of Depression on the Different Species.

This is perhaps most simply shown by the following statement:—Of the nine species in twenty years, 4 were affected in 1879, 8 in 1880, 1 each in 1881, 1882, and 1883, 2 in 1885, 2 in 1887, 3 in 1888 and 1889, 5 in 1891, 2 in 1894, 4 in 1895, 1 in 1896, and 8 in 1897.

### F. Capacity of Girth-increase as shown in Favourable Years.

To show the growth accomplished by trees of the different species under favourable circumstances I have drawn up Table VII. From this it appears that *Salix* stands, in a most marked degree, at the head with an average increase of practically three inches, and a maximum increase in a single year of four inches, the average girth being nineteen inches. In the four best consecutive years it grew fully a foot in all. No other tree comes up to this, but *Quercus conferta* comes next with an average for five consecutive years of above an inch and three-quarters, and *Ulmus montana* is third, with a little below that amount, the

TABLE VII.—Average Annual Increase in Girth in the five best consecutive years (Column A), and in the best single year (B), in Trees of different species at different sizes; (C) gives the Girth at the middle of the five years' period.

| No. | Species. | Average for five best consecutive years. | Best Single Record. | Girth in inches. |
|---|---|---|---|---|
| | | A | B | C |
| | **Under one foot in girth.** | | | |
| 19 | Salix sp. .. .. .. .. | 1·68 | 2·40 | 6 |
| 22 | Prunus Padus .. .. | 1·34 | 1·45 | 11 |
| 9 | Populus fastigiata .. .. | 1·24 | 1·35 | 11 |
| 61 | Quercus rubra .. .. | 1·18 | 1·50 | 9 |
| 80 | Œsculus Hippocastanum .. | 1·17 | 1·36 | 10 |
| 14 | Robinia Pseudacacia .. | 1·00 | 1·40 | 9 |
| 79 | Pyrus Aucuparia .. .. | ·95 | 1·10 | 10 |
| 23 | Fraxinus excelsior .. .. | ·91 | 1·15 | 10 |
| 21 | Cytisus Laburnum .. .. | ·90 | 1·05 | 11 |
| 67 | Acer Pseudoplatanus .. | ·86 | 1·05 | 9 |
| 88 | Alnus glutinosa .. .. | ·80 | 1·20 | 11 |
| 86 | Carpinus Betulus .. .. | ·78 | 1·00 | 9 |
| 16 | Quercus Ilex .. .. | ·68 | ·85 | 7 |
| 15 | Quercus Cerris . .. | ·67 | ·70 | 8 |
| 6 | Ulmus campestris . .. | ·60 | ·75 | 11 |
| | **One to two feet in girth.** | | | |
| 19 | Salix sp. .. .. .. .. | 2·97 | 4·00 | 19 |
| 55 | Quercus conferta .. .. | 1·71 | 1·80 | 19 |
| 93 | Ulmus montana .. .. | 1·62 | 1·80 | 16 |
| 74 | Acer Pseudoplatanus .. | 1·47 | 1·55 | 16 |
| 20 | Fagus sylvatica .. .. | 1·45 | 1·70 | 19 |
| 22 | Prunus Padus .. .. | 1·26 | 1·55 | 15 |
| 3 | Tilia europœa .. .. | 1·24 | 1·45 | 17 |
| 78 | Betula alba .. .. .. | 1·23 | 1·45 | 15 |
| 4 | Œsculus Hippocastanum .. | 1·21 | 1·40 | 15 |
| 2 | Fraxinus excelsior .. .. | 1·21 | 1·30 | 16 |
| | **One to two feet in girth —*continued.*** | | | |
| 12 | Acer campestris .. .. | 1·20 | 1·60 | 16 |
| 19 | Cratægus Oxyacantha .. | 1·17 | 1·65 | 14 |
| 70 | Quercus robur .. .. | 1·01 | 1·20 | 13 |
| 69 | Tilia europœa .. .. | ·83 | 1·00 | 13 |
| 8 | Pyrus communis .. .. | ·80 | ·95 | 13 |
| 79 | Pyrus Aucuparia .. .. | ·80 | ·95 | 15 |
| | **Two to four feet in girth.** | | | |
| 54 | Quercus conferta .. .. | 1·87 | 2·30 | 40 |
| 93 | Ulmus montana .. .. | 1·69 | 2·05 | 27 |
| 40 | Quercus conferta .. .. | 1·46 | 1·80 | 47 |
| 16 | Cratægus Oxyacantha .. | ·58 | ·65 | 41 |
| 45 | Quercus Ilex .. .. | ·56 | ·70 | 45 |
| 41 | Carpinus Betulus .. .. | ·49 | ·55 | 47 |
| | **From four to six feet in girth.** | | | |
| 63 | Quercus Cerris .. .. | ·70 | ·85 | 65 |
| 41 | Carpinus Betulus .. .. | ·43 | ·55 | 51 |
| | **From six to seven feet in girth.** | | | |
| 7 | Fagus sylvatica .. .. | 1·15 | 1·20 | 77 |
| 7 | The same tree .. .. | 1·00 | 1·20 | 84 |
| 4 | Castanea vesca .. .. | ·97 | 1·10 | 73 |
| 4 | The same tree .. .. | ·83 | 1·00 | 83 |
| 6 | Liriodendron tulipifera .. | ·63 | ·80 | 84 |
| 2 | Tilia europœa .. .. | ·39 | ·65 | 76 |
| 2 | The same tree .. .. | ·35 | ·40 | 80 |

respective best single years yielding 2·30 and 2·05. Their average girths were forty and twenty-seven inches.

It would be tedious to speak of all the trees in detail; suffice

it to say that the following thirteen additional species attained an annual average of an inch to an inch and a half in their best consecutive five years :—*Acer Pseudoplatanus*, *Fagus sylvatica*, *Prunus Padus*, *Populus fastigiata*, *Tilia europœa*, *Betula alba*, *Œsculus Hippocastanum*, *Fraxinus excelsior*, *Acer campestris*, *Quercus rubra*, *Cratægus Oxyacantha*, *Quercus robur*, *Robinia Pseudacacia*. These are arranged in order, *Acer Pseudoplatanus* at the head with an average of all but an inch and a half, and *Robinia* at the foot with exactly one inch; but it must be remembered that the comparison is not quite fair, as the ages of the trees were very different.

Species that appear to thrive in the Garden but yield comparatively low rates are *Carpinus Betulus*, *Pyrus communis*, *Pyrus Aucuparia*, and *Quercus Cerris*.

## II. MONTHLY RESULTS.

The trees adopted at various periods for monthly measurements were selected from those observed annually, and the reasons for choosing and abandoning successive sets, already given in the Introduction, apply with even greater force now than in the First Part of our subject.

Monthly measurements were commenced tentatively by Sir Robert Christison in 1880 upon five deciduous and six evergreen trees, but the tape he used was too coarse to yield very reliable results. In 1882 I added about thirty-five deciduous examples, and took monthly measurements of the whole, in the growing season, till 1887. The early results, down to 1882, were included in a Paper to the Royal Society of Edinburgh in 1883,* and the whole results were communicated to the Botanical Society in 1887.†

But the objections, already explained, to observations upon old and large trees induced me to abandon this set in 1887 and take up the fresh set ‡ of about thirty-five young trees, used

* "Observations on the Annual and Monthly Growth of Wood in Deciduous and Evergreen Trees." By the late Sir Robert Christison, Bart., and Dr. Christison. Trans. Royal Society of Edinburgh, 1883, pp. 45, 66.

† "On the Monthly Increase in the Girth of Trees at the R. Botanic Garden and at Craigiehall, near Edinburgh," by David Christison, M.D. Trans. Bot. Soc. Ed., 1887.

‡ "Observations on the Increase in Girth of Young Trees in the Royal Botanic Garden, Edinburgh, for five years ending 1891," by David Christison, M.D., President. Trans. Bot. Soc. Ed., 1892.

also for annual observations, selecting as far as possible such as had smooth bark and regularly cylindrical stems. These having become ineligible as a connected set in 1892—although some of them became available afterwards, as they recovered at various dates from transplantation—were replaced by the final young set of twenty trees, available from 1892 to 1895, but then disabled for my purpose by a severe pruning.

The plan followed in dealing with the monthly observations is to give *in extenso* the results for the set of 1892–95, not hitherto published, to compare these with the results yielded by the other young set of 1887–91, and to make use of the original set of older trees, 1882–87, only incidentally.

In considering the records of 1892-95, I shall first try to give the aggregate results, and then describe the conduct of each species separately, inquiring at the same time how far the results may agree with those obtained from other young trees observed in 1887-91, in so far as the same species happen to have been examined in both these periods.

In the first place, however, it is well to state that neither the number of trees of each species, nor the length of time during which they have been under observation, is sufficient to warrant the deduction of precise conclusions or definite laws. At first sight, indeed, it might seem that three specimens of a species, of similar ages, growing in the same locality, and under observation, two of them from 1887 to 1891, and the other from 1892 to 1895, should yield true averages, but that this is not so is proved by the occasional quite contradictory conduct of a tree in one year as compared with the other three or four years, or what is still more striking, by the contradictory conduct of one tree during the whole four or five years of observation, when compared with the other two trees. Neither is it always easy to account for this erratic conduct, although among probable reasons may be suggested—temporary unhealthiness, not, it may be, betrayed by the appearance of the tree; individuality of character, as when we see two trees of the same species, and equally vigorous, of which one invariably comes into leaf much earlier than the other; difference of age, which, even when slight, has, I suspect, considerable influence in early youth; difference of position, which even within narrow limits may place trees under very

different conditions of soil, exposure, etc.; unsuitability of the species to the climate or soil; the complicated effects of weather affecting species or individual trees in different ways. But notwithstanding all this, the results in some species agree quite as remarkably as in others they disagree, and while greater confidence must be placed in the former, some idea may be formed, on a careful consideration, of the general tendencies in the latter also.

## A. Aggregate Results.

### A. FOR THE MONTHS SEPARATELY.

The chief points to which attention will be directed under this head are—the aggregate increase in girth of the twenty trees due to each month in succession in each year and over the whole period; the proportion or percentage of seasonal increase due to each month in each year and on the average; the species that yield the largest and smallest proportions of seasonal increase in each month; and the largest individual scores or records in a single year that may have happened in any species in each month.

APRIL.

| Aggregate Results, 20 Trees. | 1892. | 1893. | 1894. | 1895. | Average. |
|---|---|---|---|---|---|
| Total increase, ... ... ... ... | 0·15 | 1·15 | 1·30 | 0·50 | 0·77 |
| Percentage of seasonal increase, ... | 0·6 | 4·7 | 6·0 | 2·4 | 3·4 |
| Number with no increase, ... ... | 17 | 7 | 3 | 11 | 9·5 |

The average annual increase for April amounts to only three-quarters of an inch, somewhat less than for September, at the other end of the season, and, as might be expected from our variable springs, the range, ·15 to 1·30 in amount and 0·6 to 6·0 in percentage, is very great.

The number of trees that yielded no increase in April in one or more seasons was large, the annual average default being about one half of the whole, but the proportion of the default varied as much in the different years as from 3 to 17.

| SPECIES WITH THE LARGEST PROPORTIONAL INCREASE IN APRIL. | 1892. | 1893. | 1894. | 1895. | Total. | Average. | Seasonal p.c. |
|---|---|---|---|---|---|---|---|
| Quercus robur, ... ... ... | ... | 10 | 10 | 5 | ·25 | ·06 | 9·4 |
| ,, Cerris, ... ... ... | ... | 10 | 5 | 5 | ·20 | ·05 | 7·3 |
| Fraxinus excelsior, ... ... ... | 5 | 10 | 10 | 10 | ·35 | ·09 | 7·2 |
| Betula alba, ... ... ... ... | ... | 15 | 15 | 5 | ·35 | ·09 | 5·4 |
| Robinia Pseudacacia, ... ... | 5 | 5 | 5 | ... | ·15 | ·04 | 5·2 |
| Quercus rubra, ... ... ... | ... | 10 | 10 | 5 | ·25 | ·06 | 5·0 |
| SPECIES WITH THE SMALLEST PROPORTIONAL INCREASE. | | | | | | | |
| Œsculus Hippocastanum, ... ... | ... | ... | ... | ... | ... | ... | ... |
| Tilia europœa, ... ... ... | ... | ... | 5 | ... | 5 | ·01 | 1·0 |
| Populus fastigiata, ... ... ... | ... | ... | 5 | ... | 5 | ·01 | 1·0 |
| Acer Pseudoplatanus, ... ... | ... | ... | 5 | ... | 5 | ·01 | 1·2 |
| Fagus sylvatica, ... ... ... | ... | ... | 5 | ... | 5 | ·01 | 1·2 |

Large individual scores were scarcely to be expected. *Salix* alone reached a quarter of an inch once, and did not exceed it, and ·15, the next best score, was only recorded three times, once in *Salix* and twice in *Betula*.

MAY.

| Aggregate Results, 20 Trees. | 1892. | 1893. | 1894. | 1895. | Average. |
|---|---|---|---|---|---|
| Total increase, ... ... ... ... | 2·75 | 4·70 | 2·55 | 2·95 | 2·24 |
| Percentage of seasonal increase, ... | 11·3 | 19·0 | 11·8 | 14·3 | 14·1 |

The average annual increase is two inches and a quarter, or about three times greater than in April, and the range, though not so excessive as in that month, is still high. A total absence of increase was only recorded twice, but in sixty-two of the eighty observations the amount did not reach a quarter of an inch, and in thirteen it was only ·05.

| Species with the Largest Proportional Increase in May. | 1892. | 1893. | 1894. | 1895. | Total. | Aver-age. | Seasonal p.c. |
|---|---|---|---|---|---|---|---|
| Betula alba, ... ... ... ... | ·30 | ·50 | ·35 | ·25 | 1·40 | ·35 | 21·7 |
| Fraxinus excelsior, ... ... ... | ·20 | ·30 | ·20 | ·25 | ·95 | ·24 | 19·5 |
| Prunus Padus, ... ... ... | ·25 | ·50 | ·30 | ·25 | 1·30 | ·32 | 18·0 |
| Salix sp., ... ... ... ... | ·35 | ·45 | ·30 | ·50 | 1·60 | ·40 | 14·5 |
| **Species with the Smallest Proportional Increase.** | | | | | | | |
| Robinia Pseudacacia, ... ... | 5 | 5 | 5 | 10 | ·25 | ·06 | 9·6 |
| Cratægus Oxyacantha, ... ... | 10 | 15 | 5 | 10 | ·40 | ·10 | 10·2 |
| Ulmus campestris, ... ... ... | 5 | 10 | 5 | 5 | ·25 | ·06 | 10·4 |

Several species besides those in the Table showed a *capacity* for May growth by having an occasional good score. *Acer Pseudoplatanus* once had ·35, *Fagus* and *Tilia* 30, and *Pyrus communis* 25. *Betula*, *Prunus*, and *Salix* alone reached half an inch, once each, and none of them exceeded it.

## JUNE.

| Aggregate Results, 20 Trees. | 1892. | 1893. | 1894. | 1895. | Average. |
|---|---|---|---|---|---|
| Total increase, ... ... ... ... ... | 8·05 | 7·05 | 5·80 | 5·80 | 6·67 |
| Percentage of seasonal increase, ... | 33·4 | 28·5 | 26·7 | 28·0 | 29·1 |

The average annual increase for June is six inches and three-quarters, or three times that of May, and the range is considerably less than in that month. There was no record so low as ·05, and only three of ·10. Of the eighty records, fifty-three were above a quarter of an inch, and of these seventeen were half an inch or more.

[TABLES.

| Species with the Largest Proportional Increase in June. | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1892. | 1893. | 1894. | 1895. | Total. | Aver-ge. | Seasonal p.c. |
| Acer Pseudoplatanus, ... ... | ·55 | ·50 | ·50 | ·15 | 1·70 | ·42 | 40·3 |
| Tilia europœa, ... ... ... | ·65 | ·55 | ·50 | ·25 | 1·95 | ·49 | 39·4 |
| Fraxinus excelsior, ... ... ... | ·55 | ·45 | ·40 | ·45 | 1·85 | ·46 | 38·1 |
| Species with the Smallest Proportional Increase. | | | | | | | |
| Robinia Pseudacacia, ... ... | ·10 | ·15 | ·10 | ·25 | ·60 | ·15 | 15·9 |
| Salix sp., ... ... ... ... ... | ·80 | ·60 | ·40 | ·95 | 2·75 | ·69 | 20·0 |

In June growth becomes well established, and the annual variations are much less than in the earlier months. The differences in the proportional increase of the species appear to be mainly due to normal differences in the distribution of girth-increase over the growing season in the different species. For example, the increase is much more evenly spread over the months in *Salix* than in *Acer*, so that the proportion of increase due to June is much less in the former. The highest single score was very nearly one inch in 1895 by *Salix*.

## JULY.

| Aggregate Results, 20 Trees. | 1892. | 1893. | 1894. | 1895. | Average. |
|---|---|---|---|---|---|
| Total increase, ... ... ... ... | 7·60 | 6·65 | 7·15 | 5·35 | 6·69 |
| Percentage of seasonal increase, ... | 31·5 | 27·0 | 33·0 | 26·0 | 29·4 |

The average annual increase is six inches and three-quarters, or the same as in June, and the range is similarly moderate. The records fall as low as ·10 five times, and of these two were ·05, all in 1895, when, as appears from the Table, there was a great general depression in July.

| SPECIES WITH THE LARGEST PROPORTIONAL INCREASE IN JULY. | 1892. | 1893. | 1894. | 1895. | Total. | Aver-age. | Seasonal p.c. |
|---|---|---|---|---|---|---|---|
| Populus fastigiata, ... ... ... | ·55 | ·50 | ·40 | ·40 | 1·85 | ·48 | 37·5 |
| Cytisus Laburnum, ... ... ... | ·25 | ·15 | ·35 | ·10 | ·85 | ·21 | 34·2 |
| Pyrus Aucuparia, ... ... ... | ·15 | ·25 | ·30 | ·20 | ·90 | ·22 | 34·0 |
| Tilia europœa, ... ... ... ... | ·40 | ·45 | ·45 | ·30 | 1·60 | ·40 | 32·4 |
| Œsculus Hippocastanum, ... ... | ·45 | ·40 | ·40 | ·30 | 1·55 | ·39 | 32·0 |
| SPECIES WITH THE SMALLEST PROPORTIONAL INCREASE. | | | | | | | |
| Betula alba, ... ... ... ... | ·40 | ·40 | ·40 | ·30 | 1·50 | ·37 | 23·3 |
| Robinia Pseudacacia, ... ... | ·25 | ·35 | ·20 | ·15 | ·95 | ·24 | 24·6 |
| Salix sp., ... ... ... ... ... | ·65 | ·65 | ·70 | ·85 | 2·85 | ·71 | 25·0 |

In July the variation in the comparative seasonal percentage of the species attains a decided minimum, being only from 23·3 to 37·5, whereas in June, the next steadiest month, it is 15·9 to 40·3. In July, in no less than eight species the seasonal p.c. lies between 30 and 32.

Half an inch or upwards was attained in all four years by *Salix* and *Prunus*, in two years by *Populus*, and in one year by *Fagus*, *Quercus rubra*, and *Acer campestris*. The highest single score was ·85 by *Salix*. Forty-seven other records are between a quarter and half an inch, so that only twenty of the eighty records fell below a quarter of an inch.

AUGUST.

| Aggregate Results, 20 Trees. | 1892. | 1893. | 1894. | 1895. | Average. |
|---|---|---|---|---|---|
| Total increase, ... ... ... ... | 4·90 | 4·35 | 3·80 | 4·20 | 4·31 |
| Percentage of seasonal increase, ... | 20·3 | 17·6 | 17·5 | 20·3 | 18·9 |

The annual average increase is four inches and a half, about two-thirds that of June or July and double that of May, and the

range is small. There was no increase on three occasions, and it fell to ·05 ten times, and to ·10 twelve times.

| Species with the Largest Proportional Increase in August. | 1892. | 1893. | 1894. | 1895. | Total. | Average. | Seasonal p.c. |
|---|---|---|---|---|---|---|---|
| Robinia Pseudacacia, ... ... | 20 | 25 | 25 | 45 | 1·15 | ·39 | 34·2 |
| Quercus rubra,... ... ... ... | No ob. | 25 | 30 | 50 | 1·05 | ·35 | 26·3 |
| Salix sp., ... ... ... ... | 45 | 75 | 75 | 95 | 2·90 | ·72 | 25·8 |
| Populus fastigiata, ... ... ... | 30 | 25 | 35 | 30 | 1·20 | ·30 | 24·0 |
| **Species with the Smallest Proportional Increase.** | | | | | | | |
| Fraxinus excelsior, ... ... ... | 15 | ... | 5 | 10 | ·30 | ·07 | 6·2 |
| Acer Pseudoplatanus, ... ... | 5 | 20 | 10 | 5 | ·50 | ·12 | 9·7 |
| Tilia europœa, ... ... ... ... | 15 | 10 | 5 | 20 | ·40 | ·10 | 10·1 |
| Quercus robur,... ... ... ... | 15 | 10 | 5 | ... | ·30 | ·07 | 11·7 |

The variation in the seasonal proportion of the species in August, 6·2 to 34·2, is very great compared with June or July, and even exceeds that of May. An increase of half an inch is only attained four times, of which *Salix* claims three, *Quercus rubra* being the other successful candidate. There were twenty-eight records between a quarter and half an inch, The maximum record, ·95, or nearly an inch, was by *Salix*.

SEPTEMBER.

| Aggregate Results, 20 Trees. | 1892. | 1893. | 1894. | 1895. | Average. |
|---|---|---|---|---|---|
| Total increase, ... ... ... ... ... | ·70 | ·80 | 1·10 | 1·85 | 1·11 |
| Percentage of seasonal increase, ... | 2·9 | 3·2 | 5·0 | 9·0 | 5· |
| Number with no increase, ... ... | 10 | 9 | 6 | 8 | 8·2 |

The average annual increase of September, the last month of the growing season, is a little more than an inch, only a quarter

of an inch above that of April, the first month of the season, and only a fourth that of August. The range is greatly less than in April, but much greater than in May. The number of records of no increase amounted to nearly one-half of the whole, and was not much less than in April.

SPECIES WITH THE LARGEST PROPORTIONAL INCREASE IN SEPTEMBER.

| | 1892. | 1893. | 1894. | 1895. | Total. | Average. | Seasonal p.c. |
|---|---|---|---|---|---|---|---|
| Salix sp., ... ... ... ... | 20 | 15 | 25 | 70 | 1·30 | ·32 | 10·7 |
| Robinia Pseudacacia, ... ... | ... | 10 | 15 | 30 | ·55 | ·14 | 10·5 |
| Fagus sylvatica, ... ... ... | ... | 10 | 5 | 15 | ·30 | ·07 | 6·9 |
| Betula alba, ... ... ... ... | 5 | 10 | 5 | 15 | ·35 | ·09 | 5·4 |
| SPECIES WITH THE SMALLEST PROPORTIONAL INCREASE. | | | | | | | |
| Quercus robur,... ... ... ... | ... | ... | ... | ... | ... | ... | ... |
| „ rubra,... ... ... ... | ... | ... | ... | ... | ... | ... | ... |
| Fraxinus excelsior, ... ... ... | ... | ... | ... | ... | ... | ... | ... |
| Populus fastigiata, ... ... ... | 5 | ... | ... | ... | 5 | ·01 | 1·0 |
| Pyrus Aucuparia, ... ... ... | ... | ... | 5 | ... | 5 | ·01 | 1·5 |

*Salix* alone reaches half an inch, and that only once, but with the phenomenal score of ·70. *Robinia* follows with ·30, which is perhaps still more remarkable, as its total annual increase is only about a third of that of *Salix*. No other species scored higher than ·15.

## B. FOR THE MONTHS IN GROUPS.

1. *Two periods of three months each.*—As stated in my previous paper, the division of the growing season into two periods of three months each, although the only practicable one with observations at monthly intervals, does not imply that the periods of actual growth are equal in the two divisions. Unquestionably there is a great variety both in the normal beginning and normal ending of seasonal girth-increase in the different species, but

as the beginnings and endings are very gradual it would be perhaps impossible to define their precise limits by girth measurements. On the whole, however, a division into a first half-season consisting of April, May, and June, and a second comprising July, August, and September, besides being very convenient, is probably fair enough.

It appears from the little Table annexed that in three of the years 1892 to 1895 the half-seasonal results were remarkably uniform, being nearly as 45 to 55 in favour of the second half, but that in 1893 the proportion was slightly in favour of the first half, thus reducing the four years' averages to 47, 53, in round numbers.

| | 1st Half Season. | 2nd Half Season. |
|---|---|---|
| 1892, ... ... ... ... | 45·3 | 54·7 |
| 1893, ... ... ... ... | 52·2 | 47·8 |
| 1894, ... ... ... ... | 44·5 | 55·5 |
| 1895, ... ... ... ... | 44·7 | 55·3 |
| Average, ... ... ... | 46·7 | 53·3 |

The young trees observed in 1887–91 yielded a somewhat greater superiority for the second half-season, the figures being 44, 56. This is no great difference, but when a comparison is made with the adult and aged trees of 1882–87 the superiority of the second half in them is much more marked, the figures being 35, 65, proportions which are very little affected, as I find, by limiting the comparison to the species which are represented in both sets of trees. Thus, the result arrived at in 1891—that adult and old trees have a greater tendency than young ones to throw their main girth-increase into the second half-season—is amply confirmed by the more recent observations.

The variation or range of the half-seasons would have been almost *nil* but for the exceptional year 1893; even with it the figures are only 44 to 52 for the first half and 48 to 55 for the second, in round numbers.

2. *Three periods of two months each.*—Dividing the growing season into equal first, middle, and last periods, it comes out that the girth-increase in the first was less than in the last on the average, though not in the year 1893, but that both, as a matter of course, were much below the middle, in which nearly three-fifths of the whole seasonal increase took place, whereas the first period claimed only a sixth and the last one quarter of the whole.

| | First. | Middle. | Last. |
|---|---|---|---|
| 1892, ... ... ... ... | 11·9 | 64·9 | 23·2 |
| 1893, ... ... ... ... | 23·7 | 55·5 | 20·8 |
| 1894, ... ... ... ... | 17·8 | 59·7 | 22·5 |
| 1895, ... ... ... ... | 16·7 | 54·0 | 29·3 |
| Average, ... ... ... | 17·5 | 58·5 | 24·0 |

The annual variation or range was much greater in the first period than in the others, being in the proportion of two to one, whereas in the last it was as three to two, and in the middle period as six to five. The excessive variation of the first period is no doubt due to the great irregularity in the arrival of spring in our climate. In the two midsummer months growth is well established, and therefore is much steadier. In the two autumn months the girth-increase begins to die away, and therefore again becomes more irregular, but probably it is less affected by climatic variations than in the spring months, and hence its range is less.

3. *Six periods of one month each.*—The Table of monthly percentages shows that the first and second months are exceeded by the last and second last months respectively, but only on an

[PERCENTAGE.

*Percentage of Monthly Girth Increase in Twenty Young Deciduous Trees for Four Years,* 1892-1895.

| | April. | May. | June. | July. | August. | Sept. |
|---|---|---|---|---|---|---|
| 1892, - - | 0·6 | 11·3 | 33·4 | 31·5 | 20·3 | 2·9 |
| 1893, - - | 4·7 | 19·0 | 28·5 | 27·0 | 17·6 | 3·2 |
| 1894, - - | 6·0 | 11·8 | 26·7 | 33·0 | 17·5 | 5·0 |
| 1895, - - | 2·4 | 14·3 | 28·0 | 26·0 | 20·3 | 9·0 |
| Average, | 3·4 | 14·1 | 29·2 | 29·4 | 18·9 | 5·0 |
| AVERAGE OF THIRTY YOUNG DECIDUOUS TREES FOR FIVE YEARS, 1887-1891. | | | | | | |
| | 1·5 | 12 | 31 | 30 | 20·5 | 5·0 |

average, as in the four years April twice exceeded September, and May once exceeded August. The proportions of June and July are almost identical, and of course greatly exceed those of the other months, even August. When compared with the trees of 1887–91 as shown in the Table there is a close correspondence, the only great difference being in the April proportion, the month in which disproportion is almost inevitable. Stated roundly, April claims $\frac{1}{30}$ of the annual girth-increase, May $\frac{1}{8}$, June and July not far from $\frac{1}{3}$ each, August $\frac{1}{5}$, and September $\frac{1}{20}$.

As to the variation or range in the months, it is, as might be expected, extreme in April, the amount of increase being nearly twelve times greater in the best year than in the worst, whereas even in September the best is only three times greater than the worst. May follows next in the ratio of less than two to one, while in June, July, and August the variation is comparatively trifling.

4. *Order of precedence of the months in the amount of girth-increase.*—The sequence in the case of the young trees of 1892-95 is as follows:—July 23·4 p.c., June 29·2, August 18·9, May 14·1, September 5, April 3·4. This differs but little from the results in the thirty young trees of 1887–91, for, although the positions of June and July are reversed, the difference between the two months in both sets of observations is very trifling. The sequence and proportions for 1887–91 are:—June 31, July 30, August 20·5, May 12, September 5, April 1·5.

## B. Results in the Species Individually.

In treating the Second Part of this Division of my subject, a tabular view of the results, followed by remarks, is given for each species. Each Table is constructed so as to show, first, the amount and p.c. for each month and for the half-seasons in the single tree of the set 1892-95. The corresponding p.c. for the other sets are then given. The last column gives the girth of the trees at the end of the observations upon them. The remarks that follow bear chiefly upon the proportions of the half-seasonal increase, and of the monthly increase. Finally, the highest record for each month is given, to show the capacity of growth of each species in each month under the most favourable circumstances.

The detailed records for the sets of 1884-87 and 1888-91, formerly published, could not be reproduced here without unduly swelling the bulk of this Paper, but many quotations from them occur in the text.

### No. 20.—Fagus sylvatica.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at the end of the Observations. |
|---|---|---|---|---|---|---|---|---|---|
| 1893. | ... | 30 | 50 | 45 | 35 | 10 | 80 | 90 | ... |
| 1894. | 5 | 15 | 50 | 40 | 25 | 5 | 70 | 70 | ... |
| 1895. | ... | 10 | 35 | 30 | 30 | 15 | 45 | 75 | ... |
| Total, | 5 | 55 | 135 | 115 | 90 | 30 | 195 | 235 | 17 |
| P.C. - | 1·2 | 13·0 | 31·3 | 26·7 | 20·9 | 6·9 | 45·5 | 54·5 | ... |
| Two Young Beeches, 1888-91. | | | | | | | | | |
| P.C. - | 0·5 | 8·0 | 32 | 34 | 23 | 2·5 | 40·5 | 59·5 | 13, 15 |
| Four Adults, 1884-87. | | | | | | | | | |
| P.C. - | 4·1 | 8·2 | 25·6 | 31·4 | 24·8 | 5·9 | 37·9 | 62·1 | 64, 70, 80, 81 |
| Five Adult and Aged (Craigiehall), 1884-87. | | | | | | | | | |
| P.C. - | 1·7 | 10·3 | 27·6 | 38·3 | 18·1 | 4·0 | 39·6 | 60·4 | 138, 121, 101, 78, 66 |

The half-yearly results in No. 20 show a sufficiently well marked preponderance of the second half, although it is less evident than in the other groups given in the Table, whether of young or old trees.

The monthly amounts and proportions indicate that the species is rather late in beginning to grow, and that the increase is comparatively small in the first two months. The four adults of 1884-87, indeed, have a fair proportion in April, but in May it is correspondingly small. In No. 20 June yields the highest increase, but it is not much above July. In the other sets it is the reverse, but the superiority of July is well marked only in the old trees. The united percentage of June and July is 58 in No. 20; 66, 57, and 66 in the other sets. On the whole the species continued to increase in girth well on to the end of the season.

The highest records in each month of No. 20 were 5 in April, 30 in May, 50 in June, 45 in July, 35 in August, and 15 in September. Taking in the three sets of older observation published in my former Papers, the figures are but little raised except in July. The highest there are April 15, May 30, June 55, July 60, August 40, and September 15.

[QUERCUS ROBUR.

## No. 10.—Quercus robur.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at end of Observations. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | ... | 15 | 30 | 30 | 15 | ... | 45 | 45 | ... |
| 1893. | 10 | 15 | 20 | 20 | 10 | ... | 45 | 30 | ... |
| 1894. | 10 | 10 | 20 | 20 | 5 | ... | 40 | 25 | ... |
| 1895. | 5 | 10 | 15 | 5 | 0 | ... | 30 | 5 | ... |
| Total, | 25 | 50 | 85 | 75 | 30 | ... | 160 | 105 | 13 |
| P.C. - | 9·4 | 18·8 | 32·1 | 28 | 11·7 | ... | 60·3 | 39·7 | ... |
| Four Young Oaks, 1887-91. | | | | | | | | | |
| P.C. - | 1·5 | 15·5 | 17·5 | 40 | 21 | 4·5 | 34·5 | 65·5 | 11, 10, 8, 8 |
| Old Oak (Craigiehall), 1884-87. | | | | | | | | | |
| P.C. - | 7 | 24 | 7 | 41 | 21 | ... | 38 | 62 | 80 |

The results for the half-seasons in No. 10 are completely at variance with those for the other four young trees and for the old oak at Craigiehall. The incidence of the half-seasonal growths is greatly in favour of the first half in No. 10, and as much in favour of the second half in the others. No. 10, also, in place of agreeing with the young trees in having a very small April growth and a substantial September growth, corresponds with the old tree in having a large April proportion and no increase in September at all.

The difference may be partly explained by the manifestly increasing and abnormal deficit in No. 10 in the second half-season, which in the fourth year fell almost to zero. The uniformity in the records of the other four young trees tends to prove that their results are normal on the whole. Of the eighteen observations thirteen yield a great preponderance in the second half; in two the half-seasons are equal; and the three in which the first preponderates all happened in one year, and appear therefore to be due to a special failure, analogous to that of No. 10,

although in the latter the failure continued from season to season.

On the whole, therefore, it seems probable that the normal conduct of the very young British Oak is to throw its growth mainly into the second half of the season.

None of the Oaks yield remarkably large individual scores. The highest records in young and old are—April, 10; May, 30; June, 30; July, 40; August, 40; September, 10. So that there is not a single instance in any month of half an inch increase.

## No. 15.—Quercus Cerris.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at end of Observations. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | ... | 10 | 25 | 25 | 15 | ... | 35 | 40 | ... |
| 1893. | 10 | 10 | 25 | 15 | 10 | ... | 45 | 25 | ... |
| 1894. | 5 | 5 | 10 | 30 | 5 | 5 | 20 | 40 | ... |
| 1895. | 5 | 10 | 15 | 20 | 15 | 5 | 30 | 40 | ... |
| 1896. | 5 | 30 | 10 | 20 | 5 | ... | 45 | 25 | ... |
| 1897. | 5 | 10 | 15 | 20 | 15 | ... | 30 | 35 | ... |
| Total, | 30 | 75 | 100 | 130 | 65 | 10 | 205 | 205 | ... |
| P.C. - | 7·3 | 18·3 | 24·4 | 31·7 | 15·8 | 2·5 | 50 | 50 | 10 |
| Two Well-Grown Trees, 1884-87, 1887-91. | | | | | | | | | |
| P.C. - | 2 | 24 | 14 | 34 | 20 | 6 | 40 | 60 | 63, 43 |

Although the half-season growths are exactly equal in No 15 on an average, they vary exceedingly from year to year; sometimes the first half greatly predominates, but in other years it is the reverse. This is probably due to youth, as in the two well-grown trees, one of which was at Craigiehall, the predominance of the second half-season is quite pronounced in every record.

The discrepancies between the young No. 15 and the two well-grown trees are not so great as between the young No. 10

and the other examples of *Quercus robur*, but they are great enough. They appear to be chiefly due to an almost invariable and remarkable deficiency in June in the older trees, whereby the amount is actually much less than in May. But for this strange anomaly the half-seasons would be about equal, as in No. 15. Another difference is that the percentage of April is greater, and of September less, in the young tree than in the older ones.

The highest individual records, including the three trees, were 10 in April, 20 in May, 25 in June, 30 in July, 30 in August, and 15 in April.

### No. 18.—Quercus rubra.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1890. | ... | 10 | 20 | 40 | 15 | 5 | 30 | 60 | ... |
| 1891. | ... | 10 | 15 | 45 | 25 | 5 | 25 | 75 | ... |
| 1892. | ... | 10 | 30 | 50 | 25 | ... | 40 | 75 | ... |
| 1893. | 10 | 20 | 45 | 45 | 30 | ... | 75 | 75 | ... |
| 1894. | 10 | 15 | 25 | 35 | 50 | ... | 50 | 85 | ... |
| Total, | 20 | 65 | 135 | 215 | 145 | 10 | 220 | 370 | 11 |
| P.C. - | 3·4 | 11·0 | 22·8 | 36·5 | 24·6 | 1·7 | 37·2 | 62·8 | ... |

The half-season results show a great preponderance in favour of the last, and this happened in every year of the five but one, when they were equal. The April proportion is small, but if the observations had been confined to the first three years it would have been nil, showing the necessity of a large number of years to give a fair average in the weak months of April and September, in which last month the percentage is even less. The proportion for August is high, higher than for June, and July is decidedly the best month. The record of 50 in August 1894 is very remarkable. It is very large for that month in any tree, and is the maximum of its year.

The highest individual records for each month were—for April 10, May 20, June 45, July 50, August 50, September 5.

## THE GENUS QUERCUS.

Five species of *Quercus*, comprising ten young and four adult trees, have been under observation at various periods, two of which — *Q. conferta* and *Q. Ilex*—have been dealt with in my Paper of 1892. Taking the whole, the following have showed a decided preference for the second half-season :—

| | | |
|---|---|---|
| Quercus robur—four young trees ... ... ... ... | 35 | 65 |
| ,, ,, —one adult tree ... ... ... ... | 38 | 62 |
| ,, conferta—three young trees ... ... ... | 39 | 61 |
| ,, Cerris—two adult trees ... ... ... ... | 40 | 60 |
| ,, rubra—one young tree ... ... ... ... | 37 | 63 |
| ,, Ilex—one young tree ... ... ... ... | 25 | 75 |

On the other hand, of an apparently exceptional character were—

| | | |
|---|---|---|
| Quercus Cerris—one very young tree... ... ... ... | 50 | 50 |
| ,, robur—one young tree, 1892-95 ... ... ... | 60 | 40 |

In the first of these the result may be due to extreme youth, and we have already given reasons why the results in the second may be abnormal.

*Q. conferta* is the most reliable species, as the three trees were vigorous, quick growers, and behaved with great uniformity. In it, therefore, the superiority of the second half-season is well made out, and this is the more remarkable as its April growth was steadier and larger than in any other kind of Oak or any other species under observation. In the other species of Oaks, indeed, the April increase was very small.

Apparently exceptional points in the genus are the low rate of June-increase in a large proportion of the trees, but most marked in the two adult examples of *Q. Cerris* and the old Craigiehall tree, and the large percentage of August-increase in *Q.*

*rubra.* As to the first point, the following remarks occur in a previous Paper:—*

"I have made a separate study of this genus, as there seems to be a tendency in it to early vigour, followed by a period of slower growth. This is seen most unequivocally in the three Turkey Oaks, in all of which the June percentage is much exceeded by that of May on the one side and July on the other,

| No. | | April. | May. | June. | July. |
|---|---|---|---|---|---|
| 63 | Q. Cerris . | ... | 28 | 17 | 31 |
| 43 | ,, . | 2 | 20 | 11 | 37 |
| 10* | ,, . | 3 | 22 | 6·5 | 35 |
| | Average . | 1·5 | 23 | 11·5 | 34 |
| 40 | Q. conferta . | 8 | 6·5 | 20 | 35·5 |
| 54 | ,, . | 9 | 9 | 29·5 | 34 |
| 55 | ,, . | 9 | 13 | 22·5 | 34 |
| | Average | 8·7 | 9·5 | 26 | 34·5 |

* At Craigiehall.

| No. | | April. | May. | June. | July. |
|---|---|---|---|---|---|
| 72 | Q. robur . | 2 | 20·5 | 22·5 | 39 |
| 12 | ,, . | 7 | 24 | 7 | 41 |
| 2 | ,, . | ... | 20·5 | 13 | 43·5 |
| 70 | ,, . | 2·5 | 12·5 | 16 | 38 |
| 1 | ,, . | ... | 11 | 18 | 42 |
| | Average . | 2·3 | 17·7 | 15·8 | 40·7 |
| 44 | Q. palustris | 10 | 18 | 16 | 41 |
| 61 | Q. rubra . | 2 | 15 | 20 | 39 |

the general average of the three for from four to five years being 23 for May, 11·5, or exactly half, for June, and 34 for July. In the three Hungary Oaks, the most vigorous growers in early spring of all my deciduous trees, the same tendency is shown, but at an earlier stage and in a considerably less degree, the general proportions being 8·7 for May and 9·5 for June. The general average of the five British Oaks is 17·7 for May and 15·3 for June, in strong contrast with the proportions for thirty trees in mass, which are 12 for May and 31 for June. In *Q. palustris*, not a reliable specimen, however, June is slightly below May. In *Q. rubra* there is no actual inferiority, yet the tendency to it is probably shown by its May increase being one-third above that of the general average of trees, and the June increase one-third below it.

* Trans. and Proc. Bot. Soc., Ed., March 1892, p. 314.

## No. 4.—Œsculus Hippocastanum.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | ... | 10 | 45 | 45 | 35 | ... | 55 | 80 | ... |
| 1893. | ... | 20 | 45 | 40 | 30 | 5 | 65 | 75 | ... |
| 1894. | ... | 20 | 20 | 40 | 15 | 10 | 40 | 65 | ... |
| 1895. | ... | 10 | 30 | 30 | 30 | 5 | 40 | 65 | ... |
| Total, | ... | 60 | 1·40 | 1·55 | 1·10 | 20 | 200 | 285 | ... |
| P.C. - | ... | 12·3 | 29·0 | 32·0 | 22·7 | 4·0 | 41·3 | 58·7 | 18 |
| Two Young Trees, 1887-91. | | | | | | | | | |
| P.C. - | ... | 9·0 | 31·0 | 34·5 | 22 | 3·5 | 40 | 60 | 11, 13. |

No. 4 is in agreement with the two trees of the earlier period, not only in the general particulars, but in details and degree. The second half-season predominates, there is no increase in April and little in September, July is the best month, and the percentage for August is high. The best individual records in the three trees are 20 in May, 50 in June, 45 in July, 35 in August, and 10 in September.

## No. 16.—Acer Pseudoplatanus.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | ... | 10 | 55 | 35 | 5 | 5 | 65 | 45 | ... |
| 1893. | ... | 35 | 50 | 30 | 20 | 5 | 85 | 55 | ... |
| 1894. | 5 | 5 | 50 | 45 | 10 | 5 | 60 | 60 | ... |
| Total,* | 5 | 50 | 155 | 110 | 35 | 15 | 210 | 160 | ... |
| P.C. - | 1·3 | 13·5 | 41·9 | 30 | 9·4 | 3·9 | 56·7 | 43·3 | 16 |
| Three Young Trees, 1887-91. | | | | | | | | | |
| P.C. - | 0·5 | 13 | 42·5 | 30 | 13 | 1 | 56 | 44 | 15, 14, 8 |

* I have omitted 1895, as in that year the increase suddenly fell off to less than half an inch, indicative of some abnormal condition.

The correspondence between the single tree of the recent period and the three earlier ones is even more marked than in the last species (Horse Chestnut). Indeed, it is almost precise in every particular, with the trifling exception that the increase is more equally diffused over August and September in No. 16 than in the others. There is an appreciable though not excessive preponderance of the first half-season, due to the unusually large proportion of 42 per cent. of the increase being in June. 72 per cent. of the increase takes place in the two months June and July. The Sycamore is the first among forest trees to be in full foliage in the Edinburgh district, yet the girth-increase is slow to start, and is slight in May. It makes amends, however, by rushing on quickly in June. The best single records per month are 5 in April, 35 in May, 60 in June, 50 in July, 35 in August, and 5 in September.

### No. 12.—Acer campestris.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | 5 | 20 | 35 | 55 | 45 | 5 | 60 | 105 | ... |
| 1893. | 10 | 20 | 30 | 35 | 30 | 5 | 60 | 70 | ... |
| 1894. | 5 | 10 | 40 | 35 | 10 | 5 | 55 | 50 | ... |
| 1895. | ... | ... | 20 | 10 | 5 | ... | 20 | 15 | ... |
| 1896. | ... | 15 | 30 | 40 | 15 | ... | 45 | 55 | ... |
| 1897. | ... | 10 | 25 | 25 | 30 | ... | 35 | 55 | ... |
| Total, | 20 | 75 | 180 | 200 | 135 | 15 | 275 | 350 | ... |
| P.C. - | 3·2 | 12 | 28·8 | 32 | 21·6 | 2·4 | 44 | 56 | 19 |

The conduct of No. 12 has been most erratic. Starting in 1892 with the very large increase of 1·65, of which three-fifths were due to the last half-season, it fell off, in that half only, the next two years, till in the third the first half was slightly in excess. In the fourth year the foliage looked very sickly and some twigs

died, the increase falling to 35. In the next two years the tree revived, the increase rising to about an inch annually, still far below 1892, but with the second half-season again in excess. It seems probable, therefore, that this is the rule. The highest single records were—April 10, May 20, June 40, July 55, August 45, September 5.

I have been able to give seven years' results, as this tree was only very slightly pruned in 1896. It is the only one of the species that I have observed.

## No. 2.—FRAXINUS EXCELSIOR.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | 5 | 20 | 55 | 35 | 15 | ... | 80 | 50 | ... |
| 1893. | 10 | 30 | 45 | 25 | ... | .. | 85 | 25 | ... |
| 1894. | 10 | 20 | 40 | 45 | 5 | ... | 70 | 50 | ... |
| 1895. | 10 | 25 | 45 | 35 | 10 | ... | 80 | 45 | ... |
| Total, | 35 | 95 | 185 | 140 | 30 | ... | 315 | 170 | ... |
| P.C. - | 7·2 | 19·5 | 38·1 | 29 | 6·2 | ... | 64·8 | 35·2 | 17 |
| TWO YOUNG ASHES, 1887-91. | | | | | | | | | |
| P.C. - | 2 | 23·8 | 43·5 | 21·2 | 8·5 | 1 | 69·3 | 30·7 | 8, 10 |

The single Ash, No. 2, agrees in the main with the two younger trees of 1887-91. In both the second half-season is greatly inferior to the first, and June is by far the best month. The chief difference is the greater April growth of No. 2, but taking April and May together the proportions are almost identical.

No. 2 furnishes all the highest single scores, 10 in April, 30 in May, 55 in June, 45 in July, 15 in August, the annual increase having been much greater than in the other two, which were comparatively in their infancy.

No. 3.—TILIA EUROPŒA.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | ... | 10 | 65 | 40 | 15 | 5 | 75 | 60 | ... |
| 1893. | ... | 30 | 55 | 45 | 10 | 5 | 85 | 60 | ... |
| 1894. | 5 | 15 | 50 | 45 | 5 | 5 | 70 | 55 | ... |
| 1895. | ... | 10 | 25 | 30 | 20 | 5 | 35 | 55 | ... |
| Total, | 5 | 65 | 195 | 160 | 50 | 20 | 265 | 230 | ... |
| P.C. - | 1·0 | 13·1 | 39·4 | 32·4 | 10·1 | 4·0 | 53·5 | 46·5 | 19 |
| Two Young Limes, 1887-91. | | | | | | | | | |
| P.C. - | ... | 13·5 | 53·5 | 24·5 | 5·5 | 3 | 67· | 33· | 10, 10 |
| One Adult Lime, 1884-91. | | | | | | | | | |
| P.C. - | ... | 3 | 32·5 | 55 | 6·5 | 3 | 35·5 | 64·5 | 46 |

The results in the three sets are very contradictory in the months of June and July. The two young trees of 1887–91 raised more than half their annual increase in June, whereas the adult of 1884–91 performed the same feat in July. In No. 3 July was inferior to June, but not so remarkably as in the other two young trees. The result of all this is that the young trees agree in throwing the largest share of their growth into the first half-season, but in No. 3 the excess is slight, while in the others it is very great. On the other hand, the second half-season is greatly in excess in the adult tree. The latter, however, although healthy in appearance, grew at the rate of only about a quarter of an inch annually, so that the results are untrustworthy. The two young Limes were also slow growers, and it is probable that No. 3 gives the most reliable results. They all agree in the smallness of the increase in the first and last two months. 72 per cent. of the annual increase took place in June and July in No. 3, 77 per cent. in the other two young trees,

and 87 per cent. in the adult. The highest single records all took place in No. 2, and were 5 in April, 30 in May, 65 in June, 45 in July, 20 in August, and 5 in September.

## ULMUS MONTANA.

No Wych Elm was under monthly observation in 1892–95, but I give the results in two thriving specimens for 1888–91 :—

### No. 93, 94.—ULMUS MONTANA.

| No. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 93. | 10 | 105 | 200 | 180 | 150 | 35 | 315 | 365 | 19·55 |
| 94. | 15 | 85 | 205 | 135 | 95 | 30 | 305 | 260 | 16·35 |
| Total, | 25 | 195 | 405 | 315 | 245 | 65 | 620 | 625 | ... |
| | | | | PERCENTAGE. | | | | | |
| 93. | 1·5 | 15 | 30 | 26·5 | 22 | 5 | 46·5 | 53·5 | ... |
| 94. | 2·5 | 15 | 36·5 | 24 | 17 | 5 | 54 | 46 | ... |
| | 2 | 15 | 32·5 | 25·5 | 20 | 5 | 49·5 | 50·5 | ... |

The general result is that the two half-seasons are nearly equal. But taking details, No. 93, the more vigorous grower, although 94 is little inferior to it, has a slight preference for the second half-season, while 94 has a somewhat greater preference for the first half. The difference is somewhat greater than it would otherwise have been owing to the peculiar results in 1888, when the increase in the two trees was nearly equal in the first half, while in the second half that of 93 was just double that of 94.

June was decidedly the best month in both; the proportions of May and August were fair, but those of April and September rather insignificant.

The highest individual records were 5 in April, 30 in May, 65 in June, 50 in July, 50 in August, and 15 in September.

## ULMUS CAMPESTRIS.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | ... | 5 | 25 | 20 | 25 | ... | 30 | 45 | ... |
| 1893. | 5 | 10 | 20 | 25 | ... | ... | 35 | 25 | ... |
| 1894. | 5 | 5 | 15 | 15 | 5 | 10 | 25 | 30 | ... |
| 1895. | ... | 5 | 20 | 10 | 10 | 5 | 25 | 25 | ... |
| Total, | 10 | 25 | 80 | 70 | 40 | 15 | 115 | 125 | ... |
| P.C. - | 4·2 | 10·4 | 33·3 | 29·2 | 16·6 | 6·3 | 47·9 | 52·1 | 12 |

This species does not attain perfection in Scotland, as is indicated by the low rate of increase, only from half to three-quarters of an inch annually in this specimen. The half-seasons are nearly equal, and June is the best month, but in no month is there a better single record than a quarter of an inch.

## SALIX SP.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | ... | 35 | 80 | 65 | 45 | 20 | 115 | 130 | ... |
| 1893. | 15 | 45 | 60 | 65 | 75 | 15 | 120 | 155 | ... |
| 1894. | 25 | 30 | 40 | 70 | 75 | 25 | 95 | 170 | ... |
| 1895. | 5 | 50 | 95 | 85 | 95 | 70 | 150 | 250 | .. |
| 1896. | 25 | 55 | 55 | 75 | 65 | 25 | 135 | 165 | ... |
| 1897. | ... | 35 | 15 | 70 | 90 | 30 | 50 | 190 | ... |
| Total, | 70 | 250 | 345 | 430 | 445 | 185 | 665 | 1060 | ... |
| P.C. - | 4·0 | 14·5 | 20 | 25 | 25·8 | 10·7 | 38·5 | 61·5 | 23 |
| THE SAME TREE WHEN YOUNGER, 1888-91. | | | | | | | | | |
| P.C. - | 1·0 | 13·5 | 22·5 | 26·5 | 26·5 | 10 | 37 | 63 | 8 |

Although only one Willow was under observation, the results are probably among the most reliable of all, from the large increments all through the nine years. The tree also has been steadily under observation for the long period of nine years, which enables a comparison to be made between three years of infancy and six of youth, observations having been begun when it was a mere wand, an inch and a half in girth, and continued till it measured two feet. It will be seen from the Table that there is scarcely any difference in the monthly percentages between the earlier and later stage, a larger proportion for April in the later stage being alone noticeable. The second half-season preponderates in the large proportion of above three to two. No single month has the mastery, July and August being equal, and June not much behind them. September is unusually high, and thus the increase is more equably distributed over the growing season than in any other species.

Very high individual scores are numerous. Three times, once in June and twice in August, the tree nearly accomplished a score of an inch, but perhaps the record of nearly three-quarters of an inch in September of 1895 is more remarkable. The highest records for each month are:—April, 25; May, 55; June, 95; July, 85; August, 95; September, 70.

## No. 9.—Populus fastigiata.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | ... | 10 | 25 | 55 | 30 | 5 | 35 | 90 | ... |
| 1893. | ... | 15 | 45 | 50 | 25 | ... | 60 | 75 | ... |
| 1894. | 5 | 10 | 15 | 40 | 35 | ... | 30 | 75 | ... |
| 1895. | ... | 15 | 45 | 40 | 30 | ... | 60 | 70 | ... |
| Total, | 5 | 50 | 130 | 185 | 120 | 5 | 185 | 370 | ... |
| P.C. - | 1·0 | 10·1 | 26·4 | 37·5 | 24 | 1·0 | 37·5 | 62·5 | 14 |
| Two Young Trees, 1887-91. | | | | | | | | | |
| P.C. - | 1 | 8 | 20·5 | 34·5 | 33 | 3 | 29·5 | 70·5 | 14, 12 |

There is a substantial agreement in the main facts between No. 9 and the two of the earlier period, all of much the same age. The main increase is thrown into the second half-season very decidedly in No. 9, but still more so in the others, and July is the best month, but only to a trifling degree above August in the latter. Indeed, the percentage of 33 in August with them is almost unprecedentedly high ; *Robinia* alone slightly exceeds it, and no other species comes near it.

The best individual records are April 5, May 20, June 55, July 65, August 50, September 10.

## No. 7.—Alnus glutinosa.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | ... | 10 | 30 | 20 | 20 | 5 | 40 | 45 | ... |
| 1893. | 5 | 15 | 15 | 30 | 15 | ... | 35 | 45 | ... |
| 1894. | ... | ... | 15 | 25 | 20 | ... | 15 | 45 | ... |
| 1895. | 5 | 15 | 15 | 20 | 15 | ... | 35 | 35 | ... |
| Total, | 10 | 40 | 75 | 95 | 70 | 5 | 125 | 170 | ... |
| P.C. | 3·4 | 13·5 | 25·3 | 32·2 | 24·0 | 1·6 | 42·2 | 57·8 | 11 |
| One Young Tree, 1887-91. | | | | | | | | | |
| P.C. | 1 | 11 | 38 | 33 | 16 | 1 | 50 | 50 | 14 |

This species is not satisfactorily made out. No. 7 gives a decided superiority to the second half-season, while the half-seasons are equal in the other tree. Both, but particularly the latter, were erratic in their conduct, and it is not safe to draw any conclusions as to the monthly distribution of the species.

The highest records were April 5, May 20, June 45, July 40 August 25, September 5.

## No. 17.—BETULA ALBA.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | ... | 30 | 50 | 40 | 45 | 5 | 80 | 90 | ... |
| 1893. | 15 | 50 | 35 | 40 | 30 | 10 | 100 | 80 | ... |
| 1894. | 15 | 35 | 40 | 40 | 25 | 5 | 90 | 70 | ... |
| 1895. | 5 | 25 | 30 | 30 | 30 | 15 | 60 | 75 | ... |
| Total, | 35 | 140 | 155 | 150 | 130 | 35 | 330 | 315 | ... |
| P.C. | 5·4 | 21·7 | 24·0 | 23·3 | 20·2 | 5·4 | 51·1 | 48·9 | 20 |
| Two Young Trees, 1887-91. | | | | | | | | | |
| P.C. | 1·5 | 15 | 32·5 | 27·5 | 19 | 4·5 | 49 | 51 | 25, 14 |

No. 17 agrees closely with the other two in the half-season proportions, which are nearly equal. The chief difference in details is that the increase of the first half-season was more equably distributed in No. 17 than the others. The former was much quicker in growth, so that all the highest scores occur in its records. They are April 15, May 50, June 50, July 40, August 45, September 15.

A much larger Birch, at Craigiehall, five feet in girth, and growing at the rate of half an inch yearly, gave quite different and altogether anomalous results. During the six years' observations it had no increase whatever in April and May, the only instance in any tree of any kind I ever met with. Consequently the proportion of the first half-season, confined to the single month of June, was only 27 p.c. With all this the tree seemed quite healthy.

## No. 11.—CRATÆGUS OXYACANTHA.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | ... | 10 | 35 | 30 | 20 | 5 | 45 | 55 | ... |
| 1893. | 5 | 15 | 35 | 25 | 25 | 5 | 55 | 55 | ... |
| 1894. | 5 | 5 | 30 | 25 | 15 | 5 | 40 | 45 | ... |
| 1895. | ... | 10 | 30 | 30 | 15 | 15 | 40 | 60 | ... |
| Total, | 10 | 40 | 130 | 110 | 75 | 30 | 180 | 215 | ... |
| P.C. | 2·5 | 10·0 | 33·0 | 27·9 | 19·0 | 7·6 | 45·5 | 54·5 | 14 |
| One Young Tree, 1887-91. | | | | | | | | | |
| P.C. | 4·5 | 9·5 | 28 | 22 | 24·5 | 11·5 | 42 | 58 | 15 |

The two agree in giving a slight or moderate predominance to the second half-season and in the monthly details, except that the distribution is more equable in the earlier example, in which the increase is remarkably large at the end of the growing season, the amount for August being greater than in July, and that for September almost unprecedentedly high.

The highest scores are April 15, May 15, June 40, July 35 August 45, September 25.

NO. 1.—CYTISUS LABURNUM.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | ... | 10 | 20 | 25 | 30 | ... | 30 | 55 | ... |
| 1893. | ... | 10 | 20 | 15 | 10 | ... | 30 | 25 | ... |
| 1894. | 5 | 5 | 20 | 35 | 10 | 5 | 30 | 50 | ... |
| 1895. | ... | 10 | 20 | 10 | 5 | ... | 30 | 15 | ... |
| Total, | 5 | 35 | 80 | 85 | 55 | 5 | 120 | 145 | ... |
| P.C. | 1·9 | 13·2 | 30·2 | 32·0 | 20·8 | 1·9 | 45·3 | 54·7 | 11 |
| A YOUNG TREE, 1887-91. | | | | | | | | | |
| P.C. | 7 | 14·5 | 24·5 | 25·5 | 20 | 8·5 | 46 | 54 | 9 |

The half-yearly results in No. 1 in its two years of greatest increase are much in favour of the second period, but the reverse is true of the two less prosperous years, the general result being still in favour of the second period. These results are confirmed by the other tree in every particular. The erratic conduct in both has been too great to establish a law. The only marked difference in the two trees is the more general distribution of the increase in the earlier tree, the percentage for April and September being unusually high.

The highest individual scores are April 10, May 15, June 35, July 35, August 30, September 10.

## PYRUS AUCUPARIA.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | ... | 5 | 35 | 30 | 15 | ... | 40 | 45 | ... |
| 1893. | 5 | 20 | 35 | 25 | 5 | ... | 60 | 30 | ... |
| 1894. | 5 | 5 | 20 | 30 | 10 | 5 | 30 | 45 | ... |
| 1895. | ... | 10 | 15 | 20 | 15 | ... | 25 | 35 | ... |
| Total, | 10 | 40 | 105 | 105 | 45 | 5 | 155 | 155 | ... |
| P.C. | 3·1 | 12·9 | 34 | 34 | 14·5 | 1·5 | 50 | 50 | 14 |
| TWO YOUNG TREES. | | | | | | | | | |
| P.C. | 1·5 | 5·5 | 29·3 | 37 | 20 | 6·7 | 36·3 | 63·7 | 15, 9 |

The conduct of all three trees was erratic, except the quickest grower of the two earlier ones, which always threw the mass of its growth into the second half-season, the percentages being 28 and 72. The highest individual scores were—April, 5; May, 20; June, 35; July, 45; August, 30; September, 10.

## PYRUS COMMUNIS.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | ... | 10 | 40 | 15 | 20 | 10 | 50 | 45 | ... |
| 1893. | ... | 25 | 20 | 25 | 15 | 5 | 45 | 45 | ... |
| 1894. | ... | 10 | 20 | 25 | 10 | ... | 30 | 35 | ... |
| 1895. | 5 | 5 | 25 | 20 | 5 | 10 | 35 | 35 | ... |
| | 5 | 50 | 105 | 85 | 50 | 25 | 160· | 160 | 14 |
| | 1·6 | 15·6 | 32·8 | 26·9 | 15·6 | 7·5 | 50 | 50 | ... |

The rate of increase seems low, but I have no other specimen for comparison, and, as it has steadily decreased annually, the tree may not be in a normal condition. As it stands, the half-seasons are exactly equal. June is the best month, and the September proportion is above average. The best single scores are—April, 5; May, 25; June, 40; July, 25; August, 20; September, 10.

## No. 5.—Prunus Padus.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | 5 | 25 | 60 | 65 | 40 | 5 | 90 | 110 | ... |
| 1893. | 10 | 50 | 40 | 50 | 35 | 5 | 100 | 90 | ... |
| 1894. | 5 | 30 | 50 | 50 | 20 | 5 | 85 | 75 | ... |
| 1895. | 5 | 25 | 50 | 55 | 30 | 5 | 80 | 90 | ... |
| Total, | 25 | 130 | 200 | 220 | 125 | 20 | 355 | 365 | ... |
| P.C. - | 3·5 | 18·0 | 27·8 | 30·6 | 17·4 | 2·7 | 49·3 | 50·7 | 20 |
| One Young Tree, 1887-91. | | | | | | | | | |
| P.C. - | 2 | 8 | 36 | 32 | 18 | 4 | 46 | 54 | 13 |

The half-season proportions agree fairly well in these two trees, in giving a slight preference to the second. In the general distribution they differ in the higher percentage of No. 5 in the beginning of the season, and in its preferring July, while the other chooses June. No. 5 was much the more vigorous of the two, having the high average annual increase of an inch and three-quarters. The highest scores are all from it, except for September. They are—April, 10; May, 50; June, 60; July 65; August, 40; September, 15.

## No. 14.—Robinia Pseudacacia.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. | Girth in Inches at last Observation. |
|---|---|---|---|---|---|---|---|---|---|
| 1892. | 5 | 5 | 10 | 20 | 20 | ... | 20 | 40 | ... |
| 1893. | 5 | 5 | 15 | 15 | 25 | 10 | 25 | 50 | ... |
| 1894. | 5 | 5 | 10 | 25 | 25 | 15 | 20 | 65 | ... |
| 1895. | ... | 20 | 25 | 35 | 45 | 30 | 45 | 110 | ... |
| 1896. | 10 | 15 | 15 | 30 | 30 | ... | 40 | 60 | ... |
| 1897. | 5 | 5 | 15 | 15 | 50 | 5 | 25 | 70 | ... |
| Total, | 30 | 55 | 90 | 140 | 195 | 60 | 175 | 395 | ... |
| P.C. - | 5·2 | 9·6 | 15·9 | 24·6 | 34·2 | 10·5 | 30·7 | 69·3 | 12 |

The most remarkable fact about this stranger from a warmer clime is the general distribution over the six months, combined with a great excess of energy in the last half of the season. In one year the increase for September was no less than ·30; its percentage for that month, 10·5, is high; and as to August, it takes the premier place among the months with 34·2 per cent., and it is the only month with an individual score of half an inch.

I have no other tree of the species to compare it with, but another foreigner—a much older tree, however—has a similar but even more extreme record. This is *Liriodendron tulipiferum*, a handsome specimen, nearly seven feet in girth in 1887, when its four years' record closed. I give the monthly proportions for the two trees :—

| | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. |
|---|---|---|---|---|---|---|---|---|
| Robinia Pseudacacia ... | 5·2 | 9·6 | 15·9 | 24·6 | 34·2 | 10·5 | 30·7 | 69·3 |
| Liriodendron tulipiferum | 2 | 4 | 4 | 34 | 43 | 13 | 10 | 90 |

## C. General Conclusions from the Monthly History of the Species.

In considering some of the conclusions that may be drawn from the history of the species, it is necessary to adopt three categories according to the degree of reliability in the results obtained in the different species. The first includes the species of the period 1891–94 (in which only one example of each was observed) that yielded results in conformity with those obtained from one or more trees of their own species under observation in 1887–91. The second comprises the species in which the results for the two periods are at variance, or are otherwise invalidated. The third contains the species of which only one tree has been under observation.

The chief points to which attention will be directed are the comparative tendency in the different species to early or late increase in girth during the growing season, and the comparatively wide or limited distribution of the girth-increase over the growing season in the different species.

### *1. Species in which the resnlts for 1892-95 and for 1887-91 are in substantial agreement.*

In this category the results are naturally the most reliable, and may be held to establish fairly well the characteristics of the species included, in regard to the points under consideration.

(a.) **The comparative tendencies of the species towards early or late increase in girth during the season of growth** are shown in the Table which gives the percentage of girth-increase due to each month in the trees of 1887–91 and of 1892–95 combined, the arrangement being in the order of greatest tendency to increase in the latter half of the season.

[TABLE.

| | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. |
|---|---|---|---|---|---|---|---|---|
| Populus fastigiata, ... | 1 | 9 | 23·5 | 36 | 28·5 | 2 | 33·5 | 66·5 |
| Quercus conferta, ... | 9 | 9·5 | 20·5 | 34·5 | 23 | 3·5 | 39 | 61 |
| Œsculus Hippocastanum, | 0 | 11 | 30 | 33 | 22 | 4 | 41 | 59 |
| Fagus sylvatica,... ... | 1 | 10·5 | 31·5 | 30·5 | 22 | 4·5 | 43 | 57 |
| Cratægus Oxyacantha, ... | 3·5 | 9·5 | 30·5 | 25 | 22 | 9·5 | 43·5 | 56·5 |
| Prunus Padus, ... ... | 3 | 13 | 32 | 31 | 18 | 3 | 48 | 52 |
| Betula alba, ... ... | 3·5 | 18 | 28 | 25·5 | 20 | 5 | 49·5 | 50·5 |
| Ulmus montana, ... | 2 | 15 | 32·5 | 25·5 | 20 | 5 | 49·5 | 50·5 |
| Fraxinus excelsior, ... | 4·5 | 22·5 | 40·5 | 25 | 7 | 0·5 | 67·5 | 32·5 |

On referring back to the history of the species, where the averages for both periods, 1892-95 and 1887-91, are given, it will be seen that in *Œsculus*, *Acer*, and *Betula* these averages are almost identical as regards the half-seasons, and that in general there is a close approximation even in the monthly averages. In *Fagus*, *Fraxinus*, *Populus*, *Cratægus*, and *Prunus* the differences in the two periods are greater, but it is only a question of degree, the general tendencies being similar. *Quercus conferta* is included, although no example was under observation in either of the above periods, because the three trees of 1884-87 yielded such large and steady results, all in harmony with each other, that the laws of girth-increase are probably as well established in it as in any other species. The specimen of *Ulmus montana* observed in the last period proved an utter failure, but as the two of 1887-91 were very fine trees, I give the average as being probably reliable enough, although there were some considerable disagreements in details.

The general result is that in *Populus*, *Quercus*, and *Œsculus* the difference in favour of the second half-season is large; in *Fagus* and *Cratægus* it is comparatively small; in *Ulmus*, *Prunus*, and *Betula* there is an equality, or nearly so; and in *Fraxinus* the advantage is largely on the side of the first half-season. Taking the extremes, the proportions are as 2 to 1 in favour of the second half-season in *Populus*, and the same in favour of the first half-season in *Fraxinus*.

**(b.) The distribution of the girth-increase over the growing season** shows considerable variety in the Table, but it is difficult to indicate it systematically. One way is to set the three best consecutive months against the other three. The three best are June, July, and August, except in *Fraxinus*, which prefers May, June, and July. The percentages then are as follows:—

| | Three Best Consecutive Months. | The Other Three Months. |
|---|---|---|
| Populus fastigiata, ... ... | 88 p.c. | 12 p.c. |
| Fraxinus excelsior, ... ... | 88 | 12 |
| Œsculus Hippocastanum, ... | 85 | 15 |
| Fagus sylvatica,... ... ... | 84 | 16 |
| Prunus Padus, ... ... ... | 81 | 19 |
| Quercus conferta, ... ... | 78 | 22 |
| Ulmus montana, ... ... | 78 | 22 |
| Cratægus Oxyacantha,... ... | 77·5 | 22·5 |
| Betula alba, ... ... ... | 73·5 | 26·5 |

But this chiefly shows that certain species accomplish a considerably greater part of their increase in the three chief months than others, and therefore have presumably a less general spread over the whole period, and the comparative wideness of the spread is better seen if we take the percentages in each species due to the months of April and September united, or at the beginning and end of the season. The order is thus:—*Cratægus* 13 per cent., *Quercus* 12·5, *Betula* 8·5, *Ulmus* 7, *Prunus* 6, *Fagus* 5·5, *Fraxinus* 5, *Œsculus* 4, *Populus* 3. The result is but slightly to change the order as obtained by the first process, and to show that on the whole the seasonal distribution is widest in *Cratægus*, *Quercus conferta*, and *Betula*, and is most limited in *Fraxinus*, *Œsculus*, and *Populus*. A further examination proves that the limitation to a comparatively small increase is at both ends of the season in *Populus*, at the beginning of the season in *Œsculus* and *Fagus*, and at its end in *Fraxinus*.

To put the case in another way, it may be said in a rough way that increase in girth was going on with comparative vigour for five months in *Quercus conferta* and *Cratægus*, for four months in *Fagus*, *Œsculus*, *Prunus*, *Ulmus*, and *Betula*, and for only three in *Populus*, *Acer*, and *Fraxinus*.

(c.) **Progress of girth-increase from month to month.**—Usually there is a progressive rise from the minimum in April to a maximum either in June or July, from which the fall to September is also progressive. Sometimes the actual minimum is in September instead of April. The only exception to this progressive rise and fall is in *Quercus conferta*, in which the percentages for April and May are equal, and the observation is quite reliable, as the amounts are substantial and consistent throughout. Of course it results from what has gone before that the rise and fall are quicker or more abrupt in some species than in others.

(d.) **Highest and lowest average percentages in each month, and the species to which they were due.**—The highest for April was 9 per cent. of the annual increase in *Quercus conferta*; for May, 22·5 in *Fraxinus*; June, 42 in *Acer*; July, 36 in *Populus*; August, 28·5 in *Populus*; September, 9·5 in *Cratægus*. The lowest for April was 0·0 in *Acer*; for May, 9 or 9·5 in *Quercus conferta*, *Populus*, and *Cratægus*; June, 23·5 in *Populus*; July, 25 or 25·5 in *Fraxinus*, *Betula*, and *Cratægus*; August, 7 in *Fraxinus*; September, 0·5 in *Fraxinus*.

2. *Species in which the results for 1892-95 are at variance with those for 1887-91, or which are otherwise untrustworthy.*

The reasons for regarding as more or less questionable the results in this class have been already given in the history of the five species which it includes, and need not be repeated.

(a.) **Comparative tendencies towards early or late increase in girth.**—Taking the results for what they are worth, the first five species in the Table seem to have a decided preference for the last half of the season, while the sixth is in favour of the first half.

| | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. |
|---|---|---|---|---|---|---|---|---|
| Quercus robur, ... ... | 1·5 | 15·5 | 17·5 | 40 | 21 | 4·5 | 34·5 | 65·5 |
| Carpinus Betulus, ... | 2 | 8 | 29·5 | 27·5 | 26 | 7 | 39·5 | 60·5 |
| Pyrus Aucuparia, ... | 2 | 9·5 | 31·5 | 35·5 | 17·5 | 4 | 43 | 57 |
| Alnus glutinosa,... ... | 2 | 12·5 | 32 | 32·5 | 20 | 1 | 46·5 | 53·5 |
| Cytisus Laburnum, ... | 5 | 14 | 27 | 28·5 | 20·5 | 5 | 46 | 54 |
| Tilia europœa, ... ... | 1 | 13 | 46·5 | 28·5 | 8 | 3 | 60·5 | 39·5 |

With regard to *Quercus robur*, for the reasons given in its history I have rejected the tree of 1891–95 and adopted the average of the four young Oaks of 1887–91, as being much more likely to be truly representative. As the defaulter has been transplanted to properly prepared ground, it will be interesting to see whether it will now fall into line with the others.* The erratic conduct of the representatives of *Pyrus*, *Alnus*, and *Cytisus* defies explanation, and there was nothing for it but to take their combined averages for both periods. In *Tilia* the difference is rather of degree than kind, but is so extreme as to shut it out from the reliable list. It is probable enough, however, that the united average, which I have given, is fairly representative. *Carpinus* was not observed in 1892–95, but the two young trees of 1887–91 did not agree well, and were in total disagreement with an old tree.

(b.) **The distribution of the girth-increase over the growing season** seems to be most extended and equable in *Cytisus Laburnum*, and confined within the narrowest limits in *Tilia europœa*, in which three-fourths of the whole took place in two months.

(c.) **Progress of girth-increase from month to month.**—In none of these species, except *Quercus robur*—and that in a less degree—was there a check in the rise and fall such as was noticed in *Quercus conferta* of the previous set. In three of them the movement was of an average kind, but in *Quercus robur* a very marked rise in July, and in *Tilia* a still more marked rise in June, were noticeable.

(d.) **Highest and lowest scores in each month.**—The highest for April was 5 p.c. of the annual increase in *Cytisus*; May, 15·5 in *Quercus*; June, 46·5 in *Tilia*; July, 40 in *Quercus*; August, 21 in *Quercus*; September, 7 in *Carpinus*. The lowest for April was 1 in *Tilia*; May, 9·5 in *Pyrus*; June, 17·5 in *Quercus*; July, 28·5 in *Cytisus* and *Tilia*; August, 8 in *Tilia*; September, 1 in *Alnus*.

*3. Species in which only one young tree has been under observation.*

As we have no means of checking the results in these species

* October 1899. I find that it has done so in this the first available year since transplantation, the increase having been ·35 in the first half-season, and ·70 in the second.

by comparison, all that can be done is to give the results in the same tabular form as in the other two classes, and although there is a considerable variety in their reliability it does not seem to be practicable to divide them into categories in that respect, and it will be sufficient to point out the species which appear to be most worthy of confidence, as we go along.

| | Apr. | May. | June. | July. | Aug. | Sept. | 1st Half Season. | 2nd Half Season. |
|---|---|---|---|---|---|---|---|---|
| Robinia Pseudacacia, ... | 5 | 9·5 | 16 | 25 | 34 | 10·5 | 30·5 | 69·5 |
| Quercus rubra, ... ... | 3·5 | 11 | 22·5 | 36·5 | 25 | 1·5 | 37 | 63 |
| Salix sp., ... ... ... | 2·5 | 14 | 21 | 26 | 26·5 | 10 | 37·5 | 62·5 |
| Acer campestris, ... | 3 | 12 | 29 | 32 | 21·5 | 2·5 | 44 | 56 |
| Ulmus campestris, ... | 4 | 10·5 | 33·5 | 29 | 17 | 6 | 48 | 52 |
| Quercus Cerris, ... ... | 7·5 | 18 | 24·5 | 31·5 | 16 | 2·5 | 50 | 50 |
| Pyrus communis, ... | 1·5 | 15·5 | 33 | 27 | 15·5 | 7·5 | 50 | 50 |

The *Robinia*, always in good condition, growing consistently, and under observation for six years, may be considered reliable for so very young a tree. It threw no less than 70 p.c. of its increase into the latter half of the growing season, surpassing in this proportion all my other trees, save *Liriodendron tulipiferum*, another native of sunnier climes, in which the proportion rose to 90 p.c., but which does not appear in the Table, as it is an old tree.

If results in any single tree may be relied on as representative of its species, our *Salix* may make the claim, owing to its large increments and the regularity and consistency of its conduct during the long period of nine years.

*Quercus rubra and Q. Cerris* are not quite so favourably situated, as although they are fine, healthy trees, growing at good rates, they were somewhat erratic in conduct, due perhaps to extreme youth. *Q. Cerris* also disagrees with the two adult and very fine trees that were under observation in the earlier period.

*Ulmus campestris* and *Acer campestris* are species that can scarcely be said to thrive in Scotland, and the example of *Pyrus*

*communis* is under suspicion in regard to health, as its increase diminished year by year in place of increasing as it ought to have done in so young a tree; but taking the first year, when the increase was all but an inch, the distribution in the half-seasons was nearly the same as in the total period of four years.

As to the distribution in the four most reliable species, it may be pointed out that it is well spread over the season in all of them. Even in *Robinia*, which shows such a decided preference for the end of the season, the increase began in April in five years out of six. In *Salix* the spread is more equable over five months than in any other species under my observation, and although the proportion for April, the remaining month, is small, it is quite appreciable.

The highest records for the months are—for April, 7·5 in *Quercus Cerris*; for May, 18 in *Q. Cerris*; for June, 33·5 and 33 in *Ulmus* and *Pyrus*; for July, 36·5 in *Q. rubra*; for August, 34 in *Robinia*; and for September, 10·5 and 10 in *Robinia* and *Salix*. The lowest—in April, 1·5 in *Pyrus*; May, 9·5 in *Robinia*; June, 16 in *Robinia*; July, 25 in *Robinia*; August, 15·5 and 16 in *Pyrus* and *Q. Cerris*; September, 1·5 in *Q. rubra*.

## D. Bi-Monthly percentage of Increase in the Single Trees of Twenty Species, 1891-95.

The last form in which I show the comparative proportions of the monthly increase in girth of the different species is in bi-monthly periods for the twenty single trees of the set 1891–95, Table VIII. As previously explained, some of these trees are less reliable than others, but I give the whole for what they are worth. A few of the chief results may be pointed out.

In the first, or April-May period, a proportion of 20 p.c. and upwards, or one-fifth of the seasonal growth, was attained by five species, while in nine species it was below 15 p.c. The highest proportion was in *Quercus robur*, 28 p.c., and the lowest in *Populus fastigiata*, 12 p.c.

In the middle, or June-July period, eleven, or a little above the half of the species, attained a proportion of above 60 p.c. of the seasonal growth, and in three the proportion was below 50 p.c. The highest proportion was 72 p.c. in *Acer Pseudoplatanus*, and the lowest, 40 p.c., in *Robinia Pseudacacia*.

In the last, or August-September period, nine species, or nearly one-half, attained a proportion of 25 p.c., or one-fourth of the seasonal growth, and in four it was under 15 p.c. The highest proportion was 45 p.c. in *Robinia*, and the lowest 6 p.c., in *Fraxinus excelsior*.

## TABLE VIII.

BI-MONTHLY P.C. OF GIRTH-INCREASE IN SINGLE TREES OF TWENTY SPECIES, 1891-95, ARRANGED IN THE ORDER OF AMOUNT.

| | First Two Months. | | Middle Two Months. | | Last Two Months. |
|---|---|---|---|---|---|
| Quercus robur | 28·2 | Acer Pseudop. | 71·9 | Robinia | 45·0 |
| Betula alba | 27·1 | Tilia | 71·8 | Salix | 36·5 |
| Fraxinus excelsior | 26·7 | Pyrus Auc. | 68·0 | Fagus | 27·8 |
| Quercus Cerris | 25·6 | Fraxinus | 67·1 | Œsculus | 26·7 |
| Prunus Padus | 21·5 | Populus | 63·9 | Cratægus | 26·6 |
| Salix sp. | 18·5 | Ulmus | 62·5 | Quercus rubra | 26·1 |
| Pyrus communis | 17·2 | Cytisus | 62·2 | Alnus | 25·6 |
| Alnus glutinosa | 16·9 | Œsculus | 61·0 | Betula | 25·6 |
| Pyrus Aucuparia | 16·0 | Cratægus | 60·9 | Populus | 25·0 |
| Acer campestris | 15·2 | Acer camp. | 60·8 | Acer camp. | 24·0 |
| Cytisus Laburnum | 15·1 | Quercus rob. | 60·1 | Pyrus com. | 23·1 |
| Robinia Pseud-acacia | 14·8 | Pyrus com. | 59·7 | Ulmus | 22·9 |
| Acer Pseudoplatanus | 14·8 | Prunus | 58·4 | Cytisus | 22·7 |
| Ulmus campestris | 14·6 | Fagus | 58·0 | Prunus | 20·1 |
| Quercus rubra | 14·4 | Alnus | 57·5 | Quercus Cerris | 18·3 |
| Fagus sylvatica | 14.2 | Quercus rub. | 57·3 | Pyrus Auc. | 16·0 |
| Tilia europœa | 14·1 | „ Cerris | 56·1 | Tilia | 14·1 |
| Cratægus Oxy-acantha | 12·5 | Betula | 47·3 | Acer Pseudop. | 13·3 |
| Œsculus Hippocas-tanum | 12·3 | Salix | 45·0 | Quercus rob. | 11·7 |
| Populus fastigiata | 11·1 | Robinia | 40·5 | Fraxinus | 6·2 |

# INDEX.

# On the Life-History and Habits of Clerus formicarius, Linn.

BY

R. STEWART MACDOUGALL, M.A., D.Sc.

With Figures 11-14.

THE family Cleridæ consists of soft-skinned beetles, generally gaily coloured (the "bunting" beetles of the Germans); with elongated bodies. The legs have five-jointed tarsi, but to prove this requires, in some cases, very careful observation. In habit both imago and larva are predaceous and carnivorous; where the imagines frequent flowers it is probable that besides taking honey they prey upon insects; indeed, Perris[1] has recorded cases of flower-frequenting Trichodes devouring other flower-haunting insects. The so-called carrion-eaters found amongst old carcases, skins, and bones may frequent these chiefly to prey on the insect fauna (imago and larva) found characteristically in such places.

A note on the habits of some Cleridæ found in Britain may prove interesting, as introductory to the observations made on *Clerus formicarius*.

TILLUS ELONGATUS.—Its larva has been taken by Perris in the galleries of *Ptilinus pectinicornis*, a beetle destructive to furniture and woodwork by its borings.

TRICHODES APIARIUS.—This handsome red-and-blue beetle lays its eggs in hives, and its larva on hatching passes from cell to cell of the hive, devouring the bee-grubs. The larva of *Trichodes alvearius* has the same habit, but preys on the grubs of the mason-bee.

NECROBIA RUFICOLLIS.—The imago feeds on rotting flesh, and the larva preys upon the dipterous maggots and pupæ likely to be found on such putrefying material. The larvæ of an allied French species, *Necrobia ruficornis*, found by Perris, were preying on *Anobium paniceum*. This *Anobium* is harmful in houses to vegetable matter and to books. Perris got the various stages in a hornet's nest that had stood in his room for several years, and here the *Anobium* was being attacked by *Necrobia ruficornis*.

NECROBIA RUFIPES has been found on carcases and old bones.

CORYNETES CŒRULEUS has been recorded by Sharp[2] as entering houses and performing a useful work in destroying the *Anobium* species that mine into tables and chairs.

## Clerus formicarius.

IMAGO.—I quote Fowler's[3] description. Elongate, anterior parts clothed with long pilose hairs, head large, black, coarsely punctured, eyes finely granulate, antennæ black, last joint with apex ferruginous; thorax about as long as broad, red, with anterior portion (which is divided by a broad V-shaped furrow from the posterior portion) black, coarsely punctured, posterior angles rounded; elytra depressed, parallel-sided, black, with the base red, strongly punctured in front, finely behind, with two strong bands of thick white pubescence, one before the middle very irregular, and the other behind the middle; legs black, with tarsi more or less ferruginous.

Fig. 11.
Clerus formicarius
Imago magnified.
From nature.

Found in England, Scotland, and Ireland.

LARVA.—The larva is rosy red. It has well-marked three-jointed antennæ, and on each side of the head five small simple eyes. The dark head is followed by twelve segments, of which the first three, or thoracic (each of which carries a pair of one-clawed legs), distinguish themselves thus:—The first has a brown chitinous or horny shield almost covering the upper side of the segment; the second and third each show two small chitinous spots or plates, one on each side of the middle line. The last body-segment has also a brown shield, and the body ends in two small cerci or projections.

Fig. 12. Clerus formicarius. Larva magnified. From nature.

PUPA.—The pupa, which is not enclosed in a cocoon, lies in a chamber or cell whose inner walls are lined with a whitish or greyish silvery secretion. The head and body are beset with hairs. The antennæ lie along the ventral surface, concealed in part by the first two pairs of bent legs. The wings reach about half-way down the abdomen, the hinder or lower pair showing slightly below the upper pair, each of which comes to a point. From the end of the abdomen two outwardly-directed spines project.

Fig. 13. Clerus formicarius. Pupa magnified. After Westwood.

LIFE-HISTORY AND HABITS.—Both larva and imago are, from the forester's standpoint, in the highest degree useful. The larva lives below the bark of conifers, such as pine and spruce, feeding upon the larvæ and pupæ and beetles of injurious species that infest these trees—*e.g.*, my last specimens were taken from below the bark of a *Pinus sylvestris* which was infested with *Hylesinus palliatus*.

Fig. 14. Clerus formicarius. Pupal bed in bark. By the courtesy of Professor Pauly.

The larvæ of *Clerus formicarius* are themselves able to bore into and tunnel the bark. While making observations on this beetle I placed several of the larvæ on the outside of some thick pieces of pine-bark. These soon buried themselves in the bark, and the glass on which the pieces of bark were resting under a bell-jar often showed little heaps of bore-dust from the tunnelling of the *Clerus* larvæ. Doubtless this

power of making galleries in every direction will facilitate their moving about in the search for prey.

The perfect beetle, found in conifer woods running over the bark of standing or felled trees, is also carnivorous, subsisting on destructive bark-boring insects. In the month of July I introduced a live *Clerus* (bred out of one of my pieces of pine-bark) into a glass tube which held four live *Hylesinus palliatus*. This *Hylesinus palliatus* is a small and destructive beetle which makes crutch-shaped galleries below and in the barkof pine and spruce and larch. For a quarter of a minute the *Clerus* ran up and down the inside of the glass, and then pounced upon one of the *Hylesinus*, seizing it in the weak spot in its armour, viz., on the under surface where the head is jointed on to the thorax. I lifted the tube to examine the more closely what would follow, lens in hand, when the *Clerus* started to run up and down the sides of the tube, and though it lost its footing several times and fell to the bottom, never for a moment did it let go its victim, whose antennæ were seen to be quivering nervously. At last, coming to rest, and propping itself on its two hind legs, the *Clerus* held the *Hylesinus* up to its mouth by means of the four front legs—a position also recorded by Ratzeburg.[4] First of all, the head of the victim was bent back and emptied by means of the jaws, and then the hind part of the body gutted in the same way. Finally the elytra were broken off and the wings torn to shreds.

In watching *Clerus* feed at different times, I noticed that the seizure of the prey was always at the same place, viz., between the head and the rest of the body. After a meal the beetle seemed to spend some time in cleaning itself, pulling its front legs through its jaws and the front legs over the antennæ.

Late one evening in July I placed in one tube three live *Hylesinus palliatus* and one *Clerus*, and in another tube seven live *Hylesinus palliatus* and one *Clerus*. Examination next evening showed that all the three *Hylesinus* in the first tube had been devoured, and five out of the seven in the second tube were only represented by scattered fragments of their external parts

No records seem to exist as to the length of life of *Clerus*

larva and imago, or of the time embraced in the pupal stage. In October 1897, on dissecting some pieces of thick bark from a full-grown pine-tree, I found larvæ of *Clerus formicarius*. I placed these pieces of bark under a bell-jar in an unheated room at the Royal Botanic Garden, and allowed them to remain until April 1898, when they were removed to a window in the Laboratory. I obtained imago-issue on the following dates :—

Two on June 29, 1898.
One " " 30, "
" " July 12, "
" " " 21, "

On July 14, 1898, a piece of newly-felled pine-stem was placed in a cotton sack and four of the *lerus* imagos introduced along with a number of live *Hylesinus palliatus*. The sack was allowed to stand out exposed to all weathers. At intervals up to September 30 I made examination and found the Cleridæ alive, and now and again I added fresh *Hylesinus*. On examination the *Clerus* beetles would either be found in hiding, lying close, under a piece of loose bark or a bark-scale, or else running over the log with their characteristic active and eager movement.

On January 3, 1899, I removed the log from its sack, but could find no trace of my *Clerus* beetles. Trusting that they were in winter quarters concealed in the bark crevices, I returned the log to the sack. On opening the sack again on February 25th I noticed a *Clerus* running about. The beetles continued to live till the end of May 1899. On June 3rd, eleven months from their appearance as imagos, I found three of the four lying dead; the fourth had probably escaped by a hole in the bottom of the sack where the pine-log had worn the cotton through. These four *Clerus* beetles had appeared, after pupation, in June and July 1898.

In July 1899 I bred out another *Clerus* imago, under the following interesting circumstances. On August 24, 1898, I removed two *Clerus* larvæ from below the bark of a pine where they had been since April 15, when the piece of pine came into my possession. One of the two larvæ was placed in a

glass tube temporarily, but when I came to look for it on August 25 I found only bore-dust in the tube; the larva had buried itself in the cork.

The corked tube was then placed under a bell-jar to prevent escape of the *Clerus* larva should it bore right through the cork into the open; the tube was left undisturbed until October 12th.

On the cork being removed from the tube on October 12, the larva could not be seen, as its entrance-hole was plugged up with bore-meal. The cork was carefully cut in two and the larva found lying in the hollowed-out centre. The two parts of the cork were carefully fitted together again without disturbing the larva, and the cork then returned as the stopper of the glass tube.

At various dates up till April 14th, 1899, I looked in, and the *Clerus* still remained in the larval condition. On May 3rd the two pieces of the cork seemed to be sticking together, and a more careful looking showed the silvery whiteness with which characteristically the *Clerus* larva lines the cavity in which pupation takes place. Up till June 3rd there was no pupation, but by the next examination, on June 6th, the larva had pupated. The pupation-stage lasted till July 6th, and by July 7th the perfect insect had made its way out of the cork and was running about in the inside of the bell-jar, more than ten months from the day of the larva having entered the cork.

## LITERATURE.

1. Perris. Larves des Coléoptères, 1878, p. 215.
2. Sharp. Insects, Part II., p. 255. The Cambridge Natural History.
3. Fowler. British Coleoptera, Vol. I., p. 262.
4. Ratzeburg. Die Forstinsekten, p. 36.

# On the Life-History and Habits of Rhizophagus depressus, Fowler.

BY

R. STEWART MACDOUGALL, M.A., D.Sc.

With Figures 15-17.

In addition to the family Nitulidae to which our beetle belongs, there are several related families which number amongst them species which live below the bark of trees in the galleries made by the bark-boring beetles. The members of these families, so found, prey upon the insect enemies of the trees.

Professor Nitsche[1] mentions the families and some of the useful forestral species which have been noticed by different observers. Following Nitsche, and noting others from the literature, I summarise the families in tabular form, adding the name of the tree and the name of the pest infesting it.

[TABLE

| Family. | Name of Carnivorous Species. | Name of the Enemy of the Tree in whose Tunnels the Carnivorous Beetle was found. | Tree Infested. |
|---|---|---|---|
| Nitidulidæ | Rhizophagus depressus | Hylesinus and Bostrichus species | Various conifers |
| | Rhizophagus grandis | Hylesinus micans | Spruce |
| | Rhizophagus dispar | Pissodes piceæ | Silver fir |
| | Ips ferrugineus | | Scots pine |
| | Ips quadripustulatus | | |
| Trogositidæ | Nemosoma elongatum | Hylesinus vittatus | Elm |
| | | Lymexylon dermestoides | Beech; sometimes birch, alder, ash—rarely silver fir |
| | | Tomicus domesticus | Birch, alder, beech, oak |
| | | Tomicus Saxesenii | Oak, beech, birch, lime, poplar, fruit trees, pine, spruce |
| | | Hylesinus oleæ | Olive |
| | | Tomicus bicolor | Beech; rarely hornbeam and walnut |
| Colydiidæ | Colydium filiforme and Oxylæmus variolosus | Tomicus monographus | Oak |
| | Colydium elongatum | Platypus cylindrus | Oak |
| Cucujidæ | Læmophlœus ferrugineus | Tomicus micrographus | Pine, spruce, silver fir |
| | Læmophlœus ater | Hylesinus rhododactylus | Spruce |
| | Læmophlœus clematides | Tomicus bispinus | Clematis vitalba |

The widely-distributed family Nitidulidæ includes very diverse forms, and the species also vary in habit. Some are

found in flowers: for example, *Meligethes æneus*, the tiny shining green beetle so abundant in the flower-heads of the Cruciferæ and other plants where the larvæ feed, interfering with the production of seed; others live in putrefying organic matter, and others still, like *Rhizophagus*, are insectivorous.

The genus *Rhizophagus*, which Sharp[2] would refer to the Cucujidæ rather than the Nitulidæ, numbers in Britain some ten species, which live below the bark of trees, where they make war on the Bostrichidæ or bark-beetles.

I quote Fowler's[3] description of the imago, and his translation of Perris'[4] description of the larva, of *R. depressus*.

Fig. 15. Rhizophagus depressus. Imago magnified. From nature.

IMAGO.—Bright rust red, with suture of elytra generally darker; body depressed; head of male large, about as broad as thorax, of female, narrowed, thorax longer than broad, widest in front, thickly and very finely punctured; elytra with very finely punctured striæ, first interstice with a row of widely-separated fine punctures; second interstice widened and irregularly punctured at base. Length, 2½-3½mm.

Fig. 16. Larva of Rhizophagus depressus. After Perris.

LARVA.—Length, 6 mm., rather depressed, and in the form of an elongated oval; head narrower than the prothorax; head and prothorax reddish, the base of the latter being whitish, and all the succeeding segments except the last are reddish for their basal half and whitish for their apical half; the head is long, almost elliptical, with two long impressions; the prothorax longer than the meso- or meta-thorax, and is rounded and narrowed in front; the last segment of the body is entirely ferruginous, and is furnished on its upper surface with two distinct tubercles; this segment behind is divided into two lobes, each of which terminates in three strong teeth, on the under side is a small anal appendage which is used for progression.

Fig. 17. Rhizophagus depressus. Pupa magnified. From nature.

PUPA.—The pupa is whitish in colour, and the last segment is cleft. There are long silky hairs down the sides and very small spines over the body. Length, 4 to 5 mm.

HABITS AND METAMORPHOSIS.—There is no doubt whatever that *R. depressus* is of great service to the forester in assisting to hold in check the increase of those most troublesome enemies of woods, the bark- and wood-boring Coleoptera. Two years ago I determined the beetle for a forester in charge of extensive woods in Aberdeenshire, and asked him—in connection with certain trap trees which had been felled and allowed to lie here and there in the pine wood as lures for *Hylesinus piniperda*, the pine beetle—to make frequent examination of the trees for *Rhizophagus depressus*. The trap-trees were very successful in attracting for their egg-laying numbers of *Hylesinus piniperda*, and the forester has just written me to say that in such trees where *Rh. depressus* was plentiful nearly one-half of the *Hylesinus* larvæ were destroyed.

I have taken *Rh. depressus*, imago and larva, from under the bark of Pine and Spruce; the imago moving about the borings and the *Rhizophagus* larva (also capable of active movement) lying alongside the larva or pupa of the injurious species; *e.g.*, recently on removal of bark I got two *Rhizophagus* larvæ lying in the bed of, and attached to, a *Hylesinus palliatus* pupa. The head of one of the larvæ was sunk deep in the *H. palliatus* pupa.

In June 1898, under the bark of some pine (*Pinus sylvestris*) branches I found a number of *Hylesinus palliatus* at work, the mother galleries having been partly made. Each *H. palliatus* mother tunnel held two *Rh. depressus* imagines.

In other two cases of grown pine and spruce, the bark in each case infested by *Hylesinus palliatus* and the wood by *Bostrichus lineatus*, I got numbers of *Rhizophagus* larvæ. In October 1898 and February 1899, in the galleries of *Hylesinus piniperda* which held larvæ and pupa and dead beetles, I also found *Rh. depressus* at work.

Again, in February and March 1898, on an Austrian Pine

(*Pinus Austriaca*) infested with a *Bostrichus*, I found *Rh. depressus* larvæ, which, on being placed on the outside of the Pine and watched, entered by the holes the *Bostrichus* had made, and hid there.

In October 1898, on a Scots Pine attacked by a *Bostrichus*, I got in the mother galleries of the latter, *Rhizophagus* larvæ.

On April 15, 1898, there came into my possession a section, measuring a yard, of a well-grown Scots Pine. This was found on examination to contain below the bark hundreds of *Hylesinus palliatus* larvæ. To prevent the beetles, when these had attained maturity, from escaping into the open, the section of stem was placed in a sack made of strong cotton. On July 12th I found on the floor of the sack about one hundred larvæ, which, observed through their later stages, proved to be larvæ of *Rh. depressus*. These larvæ, on being touched, coiled themselves up; on being laid on a piece of paper or glass or board they crawled actively away in all directions. As the number was far in excess of what might have accidentally tumbled out of the bark, the natural conclusion was that they had voluntarily left the pine stem in order to undergo pupation in the ground. To make certain of this—I have since found in the literature that Perris[6] had previously recorded that the *Rhizophagus* larvæ became pupæ in the soil — I covered a large circular transparent glass plate with an inch and a half of soil, and dropped here and there over the surface of the soil fifty larvæ. In one minute all without exception had disappeared into the soil. Into a glass tumbler half-filled with pressed-down soil I also dropped twenty larvæ, and these, too, rapidly buried themselves.

Towards the end of July I found that a larva had pupated; the pupa was lying a little below the surface of the soil against the glass of the tumbler. On some of the soil being emptied from the tumbler, more pupæ were found, and also larvæ as yet unchanged. With the glass plate I also had success, as on holding it overhead and looking through the under surface the tracks of the larvæ, as these had moved along the plate after burying themselves, were plainly seen, and a number of pupæ were found lying on the plate at the bottom of the soil. As August went on these pupæ were noticed to be "browning,"

and later, on removing the soil from above two of them, *Rhizophagus depressus* walked out. On turning over more of the soil other two *Rhizophagus* beetles started to walk away, but on being touched they remained quite motionless, with their legs and antennæ drawn in. Others in the turned-out earth, not quite mature, had their heads and under surface quite red-brown, while their wing covers still remained whitish.

WHEN RHIZOPHAGUS MAY BE FOUND.—Without professing to discuss this question, Perris incidentally records that the adult beetles may be found flying in the evenings in February, and also got below the bark in May and June. He notes also that the larvæ may be got even in January, and the pupa in May and June.

As I have because of its practical importance recorded times of appearance and finding of the different stages of other Coleoptera, I give here in tabular form from my notes the months of the year in which I have taken *Rh. depressus* in any of its stages.

| MONTH. | STAGE. |
|---|---|
| January . . | (Larva. Perris.) |
| February . | Adult and Larva. |
| March . . | Larva. |
| April . . | Larva. |
| May . . | Larva. (Pupa and Adult. Perris.) |
| June . . | Larva and Adult. (Pupa. Perris.) |
| July . . | Larva and Pupa. |
| August . . | Larva, Pupa, and Adult. |
| September . | Adult. |
| October . . | Adult and Larva. |
| November . | |
| December . | |

In one case the larvæ of February and March were from a Pine log that I had kept under cover in a sack, and it is reasonable to suppose that the larvæ were present at the end of the previous October when I placed the Pine log in the sack.

The fact of the finding of different stages in the life-history

at one and the same time throughout the year seems to emphasise what I have argued strongly for in Papers on other Coleoptera—viz., that the flight-times of adult beetles are not necessarily as brief as the general teaching would make us believe, and that immediate or a comparatively quick-following death is not certainly the "nemesis for reproduction."

## LITERATURE.

1. Nitsche. Lehrbuch der Mitteleuropäischen Forstinsektenkunde, Vol. II., p. 292.

2. Sharp. Insects, Part II., p. 232. The Cambridge Natural History.

3. Fowler. British Coleoptera, Vol. II.

4. Perris. Annales de la Societé Entomologique de France, Sér. III. Vol. I., p. 599.

5. Perris, *l.c.*, p. 602.

# Enumeration of Visitors to the Royal Botanic Garden, Edinburgh, during the Years 1889-1900.

On the 1st of April, 1889, the control of the Royal Botanic Garden, Edinburgh, was vested in the Commissioners of Her Majesty's Works, and the Garden, like the Royal Gardens at Kew, became subject to the "Act for the Regulation of the Royal Parks and Gardens, 1872." From the date specified the Garden was opened to the public on Sundays, and was also opened for an extended period on Week-days. The subjoined table shows the number of visitors to the Garden on Sundays and Week-days respectively during the eleven years which have elapsed since the Garden was transferred to the Commissioners of Her Majesty's Works:—

| Year. | Total in Year. | Total on Sundays. | Most on Sunday. | Least on Sunday. | Total on Week Days. | Most on Week Day. | Least on Week Day. |
|---|---|---|---|---|---|---|---|
| *1889 | 368,219 | 187,457 | 13,935 | 129 | 180,762 | 3,834 | 50 |
| 1890 | 446,540 | 216,345 | 11,265 | 91 | 230,195 | 4,032 | 65 |
| 1891 | 454,083 | 220,543 | 9,445 | 340 | 233,540 | 3,228 | 76 |
| 1892 | 437,205 | 218,233 | 13,581 | 149 | 218,972 | 2,666 | 43 |
| 1893 | 531,232 | 271,893 | 12,860 | 45 | 259,339 | 3,197 | 40 |
| 1894 | 526,948 | 268,793 | 13,515 | 68 | 258,155 | 3,153 | 28 |
| 1895 | 516,608 | 264,497 | 15,227 | 127 | 252,111 | 5,292 | 26 |
| 1896 | 516,407 | 296,576 | 13,517 | 527 | 219,831 | 3,825 | 30 |
| 1897 | 475,210 | 271,730 | 16,001 | 74 | 203,480 | 3,153 | 20 |
| 1898 | 443,289 | 258,499 | 12,840 | 123 | 184,790 | 3,234 | 39 |
| 1899 | 461,686 | 259,424 | 15,161 | 105 | 202,262 | 2,758 | 30 |
| 1900 | 561,359 | 324,856 | 17,700 | 268 | 236,503 | 3,667 | 53 |
| ... | 5,738,786 | 3,058,846 | ... | ... | 2,679,940 | ... | ... |

* Numbers in this year for nine months only.

Number IV.



# NOTES

FROM THE

# ROYAL BOTANIC GARDEN,

# EDINBURGH.

AUGUST 1901.

CONTENTS.



GLASGOW:
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[PRICE NINEPENCE.] 

# The Cultivation of Fruit under Glass.[1]

BY

JAMES WHYTOCK,

GARDENER TO HIS GRACE THE DUKE OF BUCCLEUCH, DALKEITH.

---

## THE GRAPE.

IN complying with the request of the Regius Keeper to give two or three lectures on the cultivation of fruit under glass, I think it right to treat of the vine first, because it is by far the most extensively grown fruit under glass. The course of instruction of which these lectures form a part is, I understand, for the benefit of young men of the staff of the Royal Botanic Garden, most of them beginners. I shall therefore go more into elementary details of my subject than I would do were I speaking to those who are more experienced.

What I state to-night is what I have seen and experienced, but I don't think I will state anything new to you. The truth is the most of all our experiences are built upon the experiences of those who have gone before us. We either try to improve upon what has been practised successfully or, what is equally important, we avoid practices we have seen to be failures.

There is no crop grown in this country that has undergone such a change in its cultivation as has the grape-vine during the past forty years. It is now nearly half a century since the pioneers of the last generation of gardeners began to adopt what we now know to be reasonable and sensible means to grow good grapes. The practice of putting very heavy coverings of solid

[1] Three lectures delivered in the Lecture Hall of the Royal Botanic Garden in June, 1901, as part of the Course of Instruction provided for members of the staff.

animal manure on the borders, and of digging great holes in the vine-border and burying in them dead cows or dead pigs, was seen to produce the very worst results—thick fleshy roots which perished in winter, producing bad-coloured, ill-shanked grapes.

Those pioneers who established good grape-growing were also the first to initiate what has now become a very large industry—commercial grape-growing. Most gardeners who had reached middle age shook their heads when William Thomson built his large vineries at Clovenfords to grow grapes for market, but the prices he got—7s. 6d. to 15s. per lb.—for some years in Covent Garden, were soon seen to be too good for him to have the trade all to himself. In a few years, therefore, vineyards round London were built of a size putting Thomson's into utter insignificance, and the supply of grapes brought about a reduction in the price to a minimum of 1s. per lb. At this price the crop is not profitable, and consequently the greater part of our market grapes are poor in quality, ill-flavoured, indeed almost sour grapes. We must have fire-heat in our climate to finish our grapes properly, and the high price of coal is prohibitive when the price of grapes is so low.

I do not think I need say much upon the construction of vineries. Horticultural builders have now such large establishments and comprehensive plant and machinery that they only need to be told what a glass-house is required for, and they bring the whole material ready to put together, and erect the house with its necessary heating in very quick time. With regard to heating, it is the best economy to have abundant boiler-power and abundant surface of piping. This saves fuel, and you also thereby keep up the desired temperature without strongly-heated pipes, which are so detrimental to all vegetation.

Vineries for very early forcing should be lean-to; for mid-season the span-roof is well adapted, and gives more fruit within a given space. I think, however, it is generally admitted that a line should be drawn across the middle of England, and south of that line first-class grapes are grown in span-roofed houses, whilst north of that line the finest quality of grapes are best grown in lean-to houses. Vineries in which late grapes are to hang all through our wet winters should be constructed with a

very steep pitch; flat-roofed vineries are most prejudicial to ripe grapes hanging under them in winter.

Whilst the gardener may leave the construction of the vinery in the hands of the horticultural builder, it is essential that in every detail he superintend closely the making of the vinery border. And let me here, by way of parenthesis, say on this score to you young men, that if any one of you should be placed as an assistant where new borders are to be made, do not grumble, as I have often heard young men do, at the extra work they entail. Remember you are receiving in the work a most valuable education, without responsibility as to its success or failure, whilst the head gardener is filled with anxiety as to its success.

The bottoms of vinery borders may be said to be of two kinds—

1. Where the natural drainage is good, *e.g.* gravel. In this case six inches of broken stones laid over the bottom of the border is all that is required.

2. Where the subsoil is of an impervious or water-logged nature. In this case I have made an excellent mixture of one part cement to seven parts rough gravelly sand. Mix the whole with water, and spread all over the bottom of the border, about three inches thick, on top of a layer of ashes already put down. This bottom should not be flat. The drain for such a border is usually parallel with the outer edge of the outside border, and the bottom should slope from the back wall of the vinery to the drain. The concrete bottom will be quite hard in three days, when nine inches of broken stone may be laid equally all over it, and then all the stones covered with fresh-cut sods, the grass-side put next the stones. That completes the foundation of the border.

The depth and width of border is the next consideration.

Firstly, as to depth. Deep borders are now considered bad practice. What is desired for up-to-date grape-growing is to have the very surface of the border a close net-work of fine fibrous roots to feed upon the easily assimilated finely powdered artificial manures now specially made for feeding the vine. A depth of two-and-a-half feet, exclusive of drainage, is therefore considered enough for the border when first made.

Secondly, as to width. The inside of the house is usually all border. I am much in favour of a wide outside border, for I always notice the best and greatest number of the roots are in the outside border, even when the vines are planted inside and have a good inside border.

In making a new border for planting young vines it is bad practice to make up at once the border in its whole possible width both inside and outside; it is better to make at first a width of only three feet inside and three feet outside—that will be sufficient for the young vines for the first two years, and then three feet more may be added to both outside and inside.

The next consideration is the material of which the border is made. The soil should be of the oldest pasture land, as rich and as fibrous as you can get it. I am much in favour of skinning it from the field and carting it direct to the border, granting the border is to be two-and-a-half feet deep. I should cut up the sods into large pieces, mixing with lime-rubbish and a spadeful of half-inch bones to each barrowful of soil. I should fill up the allotted piece of border with this rough mixture to the depth of eighteen inches. For the remaining depth of one foot to be filled, I should chop the sods very much smaller, measuring it in barrowfuls, and placing it in a long narrow ridge. I should then spread over this ridge one spadeful of bone-meal and one spadeful of, say, Thomson's vine-manure to each barrowful of soil, adding a good sprinkling of finely broken lime-rubbish. This ridge being now ready for mixing, the only way I should have it done, is that the men turn it all over with their hands in order that the powdered manures may become thoroughly mixed through the soil. One foot of this mixture put on top of the one-and-a-half foot of soil already put in makes the border two-and-a-half feet deep.

This work should always if possible be done in dry weather and with the soil in a comparatively dry state, and that being so, the soil should be put into the border in layers little by little, and between each little it should get a good tramping. Loose borders soon prove an evil, encouraging thick roots to get too quickly down to the bottom of the border.

We have now got the vinery and its border, and our next consideration is the vines with which it is to be planted.

The late Wm. Thomson, senior, of Dalkeith Gardens and Clovenfords, introduced a method of raising vines from eyes, which is probably a good deal practised now, and my own experience of it leads me to say it is the best method that can be adopted for the purpose of raising vines. The method is:—Take some fresh turf-sods cut in squares in the usual manner, lay them grass-side downwards on a bed in which there is bottom-heat, then take a number of vine-eyes and insert them all over the surface of the sods at equal distances of six inches square. The time for doing this is the usual time, January or early February. When the eyes have made growth six to nine inches in length, each eye is cut all round, leaving a six-inch square of turf to each. These are now shifted into another bed and placed twelve inches apart, where they make growth three feet long. They are then cut all round again. This cutting of the roots twice causes a lot of small fibrous roots to grow, and the vines are now ready to plant out in the vinery. By the time the vines have grown to be three feet long it will be the month of May, and I have always found about the middle of May is the best time to plant a vinery with young growing vines. The process of planting in this case is of the simplest and easiest:—Take a spade or wooden shovel, get it under the sod in which your vine is growing, lift and carry to the new border, lay it on the surface, cover with a little fresh fine-chopped sods mixed with bone-meal and vine-manure, and over all place a mulch of fresh horse-droppings, give a watering, and the planting is finished. So far I advocate as the best method the raising of your own vines from eyes and the planting of them out the same early summer in their permanent quarters.

We know, however, that nurserymen all over the country grow and send out yearly immense quantities of young vines grown in pots, and so a large quantity of one-year-old vines must be planted yearly. I must refer to the treatment of these also.

About fourteen months ago I had occasion to examine the roots of young vines, planted twelve months previously, and to my astonishment I found that in planting they had simply been taken out of the pots and planted with the whole ball. Inquiring who did the work, I was told the head-gardener did it himself. I did not think that any man worthy of the name of a pro-

fessional gardener could have been found to do such a thing at this date.

On receiving one-year-old vines from a nursery with a view to planting a vinery, the first thing to do is to put them in a tank of water, and let them remain there during forty-eight hours. That will kill any phylloxera that may be on the roots. The next thing is to shake every particle of soil from the roots. If you have a melon-house with a bed and slate-slabs, sprinkle over the slabs one-and-a-half inches finely chopped sod mixed with vine-manure. Spread the roots of your vines out over the soil on slabs, then cover the roots with one-and-a-half inches of the same mixture. When the vines start to grow the roots take hold of the three inches of soil over and below them. In the middle of May, the time to plant in the vinery, take a wooden shovel and lift each vine with the soil attached to the roots, and lay it in its place on the surface of the border, covering up with an inch or two more soil and then a mulch on top of all. If this shifting from melon-house to vinery is done carefully no check will be given to growth and the vines will soon reach the top of the house. The important point gained by this method is that the roots are all on the very surface, and anyone who has grown grapes successfully knows that the roots of the vines must be there if the crop is to be a success.

Various methods have been tried to keep the roots continuously near the surface, about which I would like to say a little. The first sensational exhibits of grapes were shown by the late Mr. Fowler, of Castle Kennedy, at an International Show held in Edinburgh in 1865. He produced on that occasion very large bunches, superbly finished, of Muscats and all of the finest quality of grapes, and a bunch of White Nice sixteen pounds in weight—an unprecedented weight up to that time. I was quite a young journeyman at the time, and was allowed in the situation I was then in ten days holidays. I set off to see the vineries at Castle Kennedy and if possible find out the key of the success in grape-growing. I found there the vinery borders both inside and outside were totally covered with beds of leaves, solidly built three feet deep. These beds remained for the twelve months and were removed only to have beds of fresh leaves built in their place. The roots of the vines came up most

abundantly into the bottoms of these beds, and I was told a good quantity of guano was sprinkled in the bottom of the beds for feeding. The late Mr. Johnstone, of Glamis Castle, was foreman to Mr. Fowler, and went to Glamis about that time as gardener. Lord Strathmore built a lot of new vineries, and Johnstone followed out at Glamis the same practice of having beds of leaves on the vinery borders, and with equally good results, for he carried all before him for years in the exhibits of grapes.

Looking back, however, to these two instances of ephemeral success it is seen the vines were made to make a grand effort for a few years in their youth, and then came a great collapse, for the same vines soon became enfeebled and unfruitful.

The contrast between these vines grown in a leafy medium and, say, those grown for the last thirty years at Clovenfords is most striking. The vines planted thirty years ago at Clovenfords are as full of vigour now as ever they were, and produce as fine bunches and finish the grapes as well as one would wish to see. The feeding given to the latter all these thirty years has been solely finely powdered bone superphosphates, which always seems to attract a network of fibrous roots to the surface of the border.

Some gardeners cover the outside borders with wooden shutters. The only benefit I could ever see from that was that in a district where the rainfall is very heavy, in Ireland for instance, by putting shutters in the middle of July on the borders of a vinery filled with almost ripe Hamboro grapes, the grapes hang better through the autumn from the dry border than they would if the border had been soaked with rain. Some cover the outside border with glass, which I believe is the best covering, but in ordinary dry districts the borders are best without any covering.

Heating and airing is the next consideration, and I believe a large body of gardeners have yet to give to both these points more careful study.

The fine, large, lightly-constructed vineries we have nowadays are apt to be much too air-tight. The want of air is most prejudicial to any fruit grown under glass, and to none more so than to the vine. Of course you have the usual top and bottom

ventilation, but there are often times when it is not advisable to open air at either of these points, and yet it would be most beneficial to have a little fresh air entering the house. Some of our best grape-growers, when getting a new vinery built, allow a little space between the panes at the point when they overlap each other on the roof, and by so doing a little fresh air is admitted all over the roof. In large vineries with large panes of glass, and in which labour is scarce, these little openings all over the roof are a great benefit and prevent scorching of foliage, give to the foliage greater substance, and help colouring of the fruit as well as flavour.

It is of the greatest importance to have plenty of piping in vineries. There is nothing so hurtful to vines as overheated pipes. I would at all times rather have a house 5° or 8° below the mean temperature than force it up with very hot pipes. Abundant piping keeps up the heat without overheating.

Muscat grapes, the finest of all grapes and the most difficult to grow, require high temperature accompanied with abundance of moisture. When in flower Muscats should never be subjected to a temperature below 73°. Through the day run the temperature up to 90° even with little air, but be sure along with such a high temperature to keep the air saturated with moisture. These conditions will ensure a splendid set of fruit. Muscats require all through a mean temperature of 70°. The foliage of the Muscat is more tender than is that of any other vine, and it will not stand the same treatment with insecticides that of other vines will do.

The Black Hamboro is our best quality black grape. The unfortunate thing about it is that it does not keep long after being ripe. It may be said at the present time to be the least successfully grown of any of our black grapes, that is to say, at our Flower Shows we find worse exhibits of Black Hamboro grapes than of any other varieties. I do not think high temperatures suit it at any stage of its growth. It requires a mean temperature of 60° to give it good flavour and develop a good bloom on the berries. From the time it begins to change colour, air should be kept on the vinery night and day.

Muscat of Alexandria and Black Hamboro are the two best

grapes, and are the most appreciated on a gentleman's table. The other three varieties of grapes equally largely grown are classed as late keeping grapes—namely, Gros Colman, Alicante, and Lady Downe's.

Lady Downe's is the best of the three for quality and good keeping. It is a good grower, and when properly treated gives good bunches, and the fruit takes on a fine finish. One peculiarity of this grape is its need of a circulation of air night and day whilst forming its seeds, or, as we technically say, when stoning.

Gros Colman is more largely grown for market than any other. It is not a general favourite on gentlemen's tables, because it too often lacks flavour. The treatment, however, of it is becoming better understood, and good finished grapes of this sort are increasing. It takes a long season to grow; it requires the same temperature as Muscat; and the fruit seems to be best when it hangs till January.

West's St. Peter's is our best-flavoured winter grape. It gives a good bunch and is a good cropper. The fruit takes on good bloom, but the berries are rather small. In a house with a steep roof built specially for keeping late grapes, I have seen West's St. Peter's hang till March. This is the only grape the late Queen Victoria would have for winter, and it was largely grown at Frogmore.

It is not desirable to have grapes hanging on the vines after early February, and the bunch should therefore, when they are wanted later, be cut with a piece of the lateral growth attached. The lateral growth is then put in a bottle of water, and the bunch stood in a cool, dry fruit room. In this way grapes, particularly Lady Downe's, are often kept until June.

The early forcing of the vine is an important object in many gentlemen's gardens. The greatest favourites and most suited for this purpose are Black Hamboro, Foster's Seedling, and Madresfield Court.

The best plan for very early forcing of vines is to grow yearly a quantity of vines in pots—they can be grown to fruit the second year from eyes—fruit them once and then throw them away. Putting in eyes yearly keeps up the succession. I should start my eyes for pot-vines, in sods six inches square, in

same way as for planting out; get them as soon as possible into 10-inch pots, and grow them as strong as ever I could in these the first year without any bottom heat, and in the autumn ripen thoroughly. The following year, in March, I should reduce the balls, slightly loosening all the roots round the ball, and pot them in 12-inch pots in good fibry loam mixed with bone-meal and an artificial manure; grow them on as strong as I could, giving occasionally manure-water, and at the end of summer ripen well again. These plants ought now to be good fruiting canes, and fit for starting for early forcing.

The early forcing of pot-vines requires and is worth a special house. The best form of house is a lean-to, not very wide, say ten feet, with a brick-built pit three-and-a-half or four feet wide and the same in depth running along the front of the house. This pit should be filled with leaves, and a little stable-litter should be added to it, and thus a moist bottom heat is secured. The fruiting pot-vines should be plunged in this about the middle of November. Care must be taken that the bottom heat is not above 80°. The heat of this bed without any fire-heat will start the vines. When they have grown to show flower, the mean temperature may be 60° to 65° during the day, 10° higher at this sunless short-day period; it is pretty well a matter of fire-heat all through. It will be a great help to the vines if the air of the house can be changed during a short time each day. By the time the grapes are colouring it will be April, when the weather will admit of sufficient airing, so essential to the colouring and ripening of grapes. Black Hamboro is really the best and only grape for early forcing. Foster's Seedling is a good early white grape.

The house in which vines have been forced may for the summer and autumn be used as a melon and cucumber house, and the back wall devoted to tomato growing. Two or three shelves on the back wall may, when the vines are in it, be devoted to forcing strawberries.

For the early forcing of planted-out vines, the vines must be of some age and well-established, and indeed gradually brought up to it. If you force young vines, for instance plants that have been out say three or four years, you get a crop and destroy them for fruitfulness for ever after. In the early forcing of vines

it is usual to start to close them up at the end of November. But my own experience leads me to say that on planted-out vines started about Christmas the grapes will be nearly as soon ripe as upon those closed up a month earlier. A week or two after the days begin to lengthen is worth three times that during the shorter days.

I will now refer to the treatment of the growth of young vines in the first year of planting. I would allow all the rambling growth possible without any stopping, in order to secure all the root-action possible. When this first year's growth is well ripened I would cut the whole down to within two feet of the ground. All being right they will grow away very strongly the second year, and when half way up the roof I would stop them. At the point of stopping another growth will start away; this should be pinched out, and the growth that succeeds it will grow much stronger. The reason for stopping the vine half way is to cause the eyes on the lower portion of the rod to plump up better. This second year's growth should again be all well ripened and then cut back, leaving three feet of the second year's growth. It is customary, when planting afresh a vinery, to plant as many supernumeraries as permanent vines. In the third year a bunch or two of grapes may be taken from the permanent vines, whilst all possible may be taken from the supernumeraries, as in a year or two they will be taken out.

A word or two as to stopping lateral growths on old-established vines. I think a great mistake is often made in restricting too much the lateral growths. The vines should be four feet apart, and this allows good space for lateral growth, which makes the laterals much stronger.

The renovation of old borders, and the attempt to improve vines which have got into a bad state, often fall to the lot of a gardener. I should never have any hesitation in stripping the roots bare of any vines in a bad way, putting fresh soil into the border, and bringing the roots up to the surface. This work should be done in the early autumn to retain natural heat in the soil. I have seen the old soil of a vinery border mixed up with fresh soil and put back again ; this proved a failure and should not be done. Some gardens are unfortunately very deficient in a water-supply. The vine, if growing in thoroughly suitable

environment, requires a great deal of water. Inside borders should never be allowed to become dry; they should get a good watering in winter, and at least two good waterings during the growing season. The watering given after the thinning of grapes should be given with manure, either by washing in artificial manure or by adding made manure-water.

If a vinery border does not dry up, the material and drainage are at fault; the vines won't thrive in it.

Perhaps I should say a few words about what varieties of grapes should be grown. I went some few years ago in the month of September to see a large garden near Northampton, and was shown into a large, lofty span-roofed vinery. In this vinery nearly every known variety of grape was growing; there were a great many bunches of grapes, but I thought it the most miserable spectacle of grape-growing I had ever seen. There was not a decently coloured bunch in the lot, as might be expected, for different varieties require different temperatures, etc. The safest guide for a gardener is to grow the varieties his employer likes. Tho two best grapes are Black Hamboro and Muscat of Alexandria. Some families will have none other, and where an almost constant supply of these grapes has to be kept up, it is the most expensive form of grape-growing; neither are late keepers, and very early forcing must be done to bring in early supplies of fruit.

Madresfield Court is one of our best black grapes, and if it is to do it must have a house to itself. I first saw this grape well grown by the late Mr. Meredith near Liverpool. He had one vinery filled by one vine of it, grown on the extension-system, and it finished splendidly, as he gave it the special treatment it requires—namely, a less restriction of growth than other vines, and plenty of air. Lady Downe's is our best late-keeping grape, and I find Appley Towers keeps about as well. The former is an old and well-known grape. The latter is new, but one that has come to stay. It is a free grower, free bearer, free setter, and finishes well. West's St. Peter's is our best-flavoured winter-grape. Alicante and Gros Colman are the only other two I need mention. The latter requires Muscat treatment to give it good flavour; Alicante does not keep beyond the turn of the year. Canon Hall Muscat is in every way the finest grape, but I have

never known it to be grown in quantity successfully away from near London. It is a sight ever to be remembered to see the span-roof vineries five hundred feet long, forty feet broad, of Mr. Peter Kay at Finchley filled entirely with Canon Hall Muscat. Something suits them there that makes them grow finer than anywhere else. I conclude by saying, however, that during the past thirty years in first-class finished grape growing, as judged by the standard of taking the best prizes at all our leading exhibitions, Scotland has taken the lead, and I would express the wish that she may long continue to hold it.

## THE PEACH AND THE NECTARINE.

The cultivation of the peach in our climate can only be carried on out of doors on walls with a south aspect, and it is only in the southern portions of England that you can get peaches on open walls of a good size and of a good flavour. I have seen finer peaches grown on the open wall at Frogmore, Gunnersbury, and other places in the Thames Valley, than eould be grown in peach-cases, without fire-heat, anywhere in the north of Britain.

If a gardener located in the North of England or Scotland should in his holiday go south into Kent and visit, say, Mereworth he will observe a great difference in the fruit-gardens of the two districts. The great length of walls at Mereworth is covered with splendid peach-trees. And if his visit is in the beginning of September, he will see the splendid crop of fine fruit, which probably will arouse in him, as in Johnson's Scotsman, a wish to remain where he is. We cannot all be in Kent, however, and it has struck me on my visits to Kent that gardeners have their difficulties there also, and so we must try with the usual pluck of Scotsmen, and as good skilful gardeners, to grow good peaches even under most unfavourable circumstances.

The late Lord de Vesci, whom I had the honour to serve as gardener for five years, said to me that the peach-trees on south walls in his garden at Abbeyleix, Queen's Co., Ireland, produced good crops of peaches yearly up to the date of the potato-failure, and that some climatic change must have taken place then. In 1845 the walls were covered with good peach-trees, bearing good crops—twenty-five years later there was not a peach-tree left on

the same walls, all had died out. I may mention this was a warm district, soil inclined to be light, on a limestone bottom.

It is not the cold severity of our winters that is against our growing peaches in the open in the North, it is the sunlessness and often wetness of our climate that is the obstacle. This is proved by the very large peach-orchards that exist both in the United States and Canada. In these countries the summers are very hot, so that the wood is ripened as hard as can be, and is therefore not injured by the winter's frosts many degrees below zero. The ripening of the wood of our peach-tree is the important thing we have to look to in cultivating peach-trees, and here I wish to note observations I have made—and I have heard others say they have observed the same—in relation to ripening the wood of peach-trees in a glass case without any fire-heat.

It has been my experience that where the wood of the peach-trees is ripened in a case without fire-heat, the trees should not be pruned the same as trees ripened under glass with fire-heat. It is necessary to prune the trees in a case early in January because the buds soon after become too prominent for the necessary washing and tying. Now, we frequently have some of our very coldest weather early in February. Well, if you shorten back the leading shoots in your peach-trees, in the way usually done in heated houses, and a hard frost comes afterwards, it will kill back a considerable portion of the already pruned or wounded shoot, but the frost will not affect the shoots not shortened. From that I gather that the imperfectly ripened wood in a cold case will not stand hard frosts if cut. I therefore make it a point to cut back the wood as little as possible in a cold case.

I have seen peach-trees in a cold case grown on the spur-system, but I would not adopt it. The fruit is much smaller, although I believe you get a better set of fruit by the spur-system, probably because you have a much larger quantity of flower.

The peach and nectarine lend themselves to very early forcing. Ripe fruit can be had from the beginning of May until the end of October. Mr. Chalis, a gardener of forty years standing at Wilton, wrote recently in a gardening paper that the season of ripe peaches might be extended to the beginning of December

by a system of glass copings and screens hung in front of open walls to keep out wet and frost. Wilton is on a chalk subsoil, the driest and best possible subsoil for fruit. At most places, and particularly in Scotland, it takes much watchful care and skilful working to have presentable peaches at the end of October.

The best form of house for early forcing is a lean-to house; for later crops we usually find peach-houses a continuation of a range of lean-to vineries. Span-roof houses running north and south are the best, however, for mid-season and late crops of peaches. They afford the greatest surface of fruiting space, and from the necessity of training the trees upon both sides of the span close to the glass, the fruit is finer and larger. A form of training of peach-trees in lean-to houses much advocated is that of planting the back wall with trees and then planting trees along the front of the house and training them to a curved trellis reaching to the path. At the path the trellis is a good distance from the glass, and thus all the possible light is given the trees on the back walls. This system of having trees on the back wall and along the front of house should never be adopted unless in wide, roomy houses. A good few cases have come under my notice where the curved trellis had been done away with, and the front trees trained close to the glass, as far up as it was safe without shutting out the light from the trees on the back wall. My own observations, borne out by a great deal of the best peach-growing under glass in the eountry, leads me to say—plant your trees only at the front of the house, and train them close to the roof to the top of the house. The trees will do much better and the fruit will be finer.

Good and proper ventilation is of the utmost importance in peach-houses. For houses where you have peach-trees in flower early in January and February, instead of opening the roof in cold weather, have ventilators in the back wall that can be closed with wood shutters. This ventilation must not open to the back of the wall, but at the top of the wall with perforated gratings.

The next consideration after the construction of the house is the making of the borders. Very cold clay subsoil, or low-lying places where the water does not get away, are most prejudicial to any kind of fruit-growing, and if peaches have to be grown on

such places, it is best to make a concrete floor (one of cement to six of sandy gravel), the surface of which should be three feet below the ground-level. This floor should slope from the back wall to the outside of the front border, with a good drain running outside and parallel with the outer edge of the front border. On the concrete floor lay lines of tile drains eight feet apart running at right angles to the main drain in front, then cover the whole floor and tile drains with nine inches broken stones or rough screened gravel, and over the gravel put a layer of sods, grass-side down. That would leave a depth of border of two-and-a-half feet, because we usually raise our borders a few inches above the ground-level. The width of the outside border should be the same as the width of house. In making up new borders for peach-trees they should be made as for vines. Give just breadth enough for the trees for two years, three feet inside and the same outside, then add three feet more to serve for another two years. Peach-trees do best in every way in a heavy marly soil. They live much longer in it and give much larger fruit than in a light soil. Indeed, peach-trees never thrive right, however well manured, in a poor soil. The soil should be taken fresh from an old pasture, chopped in pieces six inches square, and if of the right kind, the only mixture wanted is well broken lime-rubbish. If the soil is of a light nature I would mix one spadeful of bone-meal with every barrowful of soil, and with the last six inches of soil on the top I would mix a good fertiliser. I have proved Thomson's vine-manure an excellent manure for peach-trees on poor soils.

In planting a new peach-house with young trees, I should plant double the number of trees required eventually to fill it, and, adhering to my conviction that training against the roof is the best, I should plant along the front of the house dwarf-trained trees, and along the middle and half way up the roof I should plant standard-trained trees with long clean stems, thus covering the whole roof in very quick time. In a year or two some of these will need removing to give the remaining ones room to grow. This removing will be a benefit rather than otherwise to the trees removed, and in gardens of fair extent there are always some worn-out trees to be replaced or vacancies to fill up. Young peach-trees, when planted in a good well-made border,

grow grossly to wood for a year or two. One way to counteract that is to make no hole when planting, but plant on the very surface. If the trees make gross wood it is a very easy matter, and without any check to the trees, to get at some of the strongest roots to cut them, and then fibrous roots will be emitted. A plan adopted by the Messrs. Rivers, who are our best authorities on such things, is to put the peach-tree in a shallow box sufficient to hold the roots, a hole is then made in the border just large enough and deep enough to bury the box; the consequent restricted growth and feeding on the surface made fibrous where wanted, resulting in the tree becoming quickly fruitful. After a year or two the box decays, the decayed wood is removed, and the roots are extended; but the tree once fruitful remains fruitful; for we know a good crop of fruit is the best preventive for gross wood. Whatever form of planting is adopted it is a good practice to lift the trees clean out of the border and replant in the same place, keeping the roots near the surface. This surface rooting or network of roots on the surface is the key to all successful fruit-growing. I have frequently observed in lifting a fruit-tree that the ball of roots is such a compact mass of fibrous roots you can lift the tree and move it where you like, and the tree never feels the shift—as is shown by the crop of fruit the following year being unaffected by the shift.

The right time for transplanting or lifting a peach-tree—merely replanting of peach-trees is important—if you wish it to fruit the following season, is when the wood is matured. This you recognise by drawing your hand along the branch lightly, when the foliage parts easily from the branch. It is, however, a great advantage if at this stage you can shift the tree still retaining its foliage; a root-action will take place before the tree goes finally to rest—this applies only to home-shifting. If you get trees from a nursery, they should be thoroughly ripened and denuded of leaf.

The peach lends itself to early forcing, but wants gradual preparation for it, and early varieties must be chosen. Trees that you have brought into flower beginning of March this year, may be brought into flower a fortnight or three weeks earlier next year, then the following year a fortnight earlier still, and so on until you get them to flower at the end of December, which

is as early as may be done to secure good crops. At the beginning of forcing, low temperatures must be the rule until the fruit is set. Begin with a mean temperature of 45° to 50° and 50° to 55°; when in flower 10° to 15° higher through the day. When peach-trees in a house are in flower, I keep on air night and day and regulate the heat in the pipes to get the desired temperature. Following this practice I find, if the trees are in fair order and have been sufficiently ripened, nearly every flower sets without any outer aid in distributing the pollen. The fruit being set, increase the temperature to 60° mean and stop giving night-air. The fruit will not swell for a bit. When the stoning period begins the fruit seems to stand still for some weeks and should not in any way be forced, indeed if this is done the fruit drops off. Until the fruit begins to swell after stoning, the temperature should not exceed 60° at night, but this critical period being over you may advance the temperature 5° or even 10° and swell the fruit to a good size. When the fruit begins to ripen, you must give a good deal of air, and expose the fruit to the sun by putting aside or removing some leaves. This gives flavour and colour to the fruit.

Unless when the trees are in flower syringing and damping daily must be attended to, and when the trees get in full foliage, heavy syringing twice daily must be given to keep down red spider, occasionally using some safe insecticide. Too much stress cannot be laid upon the way the syringing of peach-trees is done. A mere wetting of the foliage is harmful. If the trees are in full foliage, a powerful garden engine should be used, going first over the trees one way then returning upon them in the opposite way, this to be done twice daily. You can have no successful peach-culture unless you keep the foliage absolutely clean and healthy. The damping and syringing is stopped when the fruit begins to ripen, and during the ripening period dryness with a good circulation of air must be kept on night and day.

The disbudding and pruning of a peach-tree is of much importance in its good cultivation. I have seen peach-trees on a roof a frightful thicket of wood, and of course with miserable results as to a crop. As soon as the trees have set their fruit it will be time to begin disbudding. It is injurious to the trees to take off too many at first. Take off first only the fore right buds, that

is those growing straight out from the trees, and even with those, should a fruit be at the base of any one of them do not remove it entirely but pinch the shoot and leave three leaves. In about three weeks afterwards the remaining shoots will get too thick, and then another thinning may be done, leaving on every branch of the winter-pruning, one shoot at the base on the upper side of the branch, one at the extremity of the branch called the leading shoot. I should also pinch two shoots on the under side of the branch to two leaves. This practice reduces the shoots to the least possible number, in fact it is only leaving one shoot to each branch to give fruit for next year, and as you know the branches made in the peach-tree this year give us the fruit next year. I would notice here too how important it is that you secure the shoot of this year at the base of the branch of last year; by doing that you keep your trees furnished with young fruitful wood to the centres of the trees. Inattention to this will cause very unsightly, trees with fruiting wood only at the extremities. Another circumstance is to be noticed in connection with the disbudding and summer-pruning of peach-trees. In peach-trees of fairly rude health there is a tendency of some shoots about the centres of the trees to grow stronger than the rest, to grow what is termed gross. The practised eye knows them at an early stage, and they should be at once taken clean off, because they never ripen enough to bear fruit, and grow gross at the expense of the other branches, whilst if taken off the less vigorous shoots grow stronger.

Granted that the trees are growing under favourable circumstances as to the house and border, the three things to be guarded most against are:—

1. Green Fly, which shows itself at a very early stage of the tree's growth.

As a remedy for this I greatly dislike fumigating, because I have seen whole crops of well-sized peaches lying on the ground from the fumigating material getting overheated during the operation. I always use a mild insecticide, applying one, that is to say, weak, but frequently, and I use it before much fly shows itself, on the principle, prevention is better than cure. I find liquid quassia the safest insecticide for the early tender foliage of the peach. Sometimes peach-trees develop at the beginning of

their growth curled-up leaves, the inside of these being filled with fly. Insecticides applied with a syringe do not reach the fly. I find tobacco-powder dusted on them clears off the fly.

2. Red Spider.

Copious and vigorous syringing twice daily is the only sure preventive for this.

3. Mildew.

Some varieties are very subject to it. Soapy water and sulphur applied frequently keep it in check.

Dropping of the buds is probably one of the most serious things affecting the peach-tree. It happens all over the country irrespective of the circumstances under which the tree is grown. It has been long attributed chiefly to dryness at the root. A gardener who had charge of extensive peach-houses in this country, and was much troubled and puzzled over bud-dropping, went to Australia and grows peaches largely there. He says the soil in which the peaches grow there becomes at certain seasons as dry as it is possible to be, and there is never any bud-dropping. His experience leads him now to say that dryness at root is not the cause of it. Early this spring I saw peach-trees in heavy wet soil, and a large portion of the buds had dropped. I think gardeners have not discovered the cause of it. It certainly indicates weakness, and too heavy cropping of the trees is usually followed by bad bud-dropping. Trees growing vigorously and altogether in good health do not drop buds much.

The watering of the borders, especially inside ones, is very important. The borders are usually allowed to become pretty dry when the fruit is ripening and ripe, a dry atmosphere being then essential. During the autumn and winter the borders should get one or two good soakings, and one should be with good manure-water. A porous border, which is the best, will take more water than a stiff retentive border.

What I have said for the peach applies equally to the nectarine, although I think the nectarine requires rather more heat than the peach to ripen.

In a general way peaches do not do well on open walls in our northern climate, and so to obtain crops late into the autumn the walls have been covered with narrow glass houses, called peach-cases. I have had much experience with these cases, and

say decidedly they are not a success for good peach-growing. In the South of Ireland the trees in such a case come into flower in February or early March. Now we sometimes have had a heavy snowstorm in the middle of March when the trees are in full flower, and there being no fire-heat and a cold, leaden, dull sky, the result is no crop. At another time a favourable setting may give a crop, but a wet, sunless autumn admits of no good ripening. I put two pipes into one of these cases and all was changed. Good sets, well ripened fruit and wood, and much larger fruit.

The peach-cases at Dalkeith under my charge at present were put up thirty-five years ago, and much was expected from them, but I am sorry to say they have not been a success even when good crops are secured, for the fruit lacks size and flavour from want of heat. Probably one of the best late cases and houses of this kind is at Drumlanrig. The south boundary wall of the garden there fell down, and instead of building a new wall, a span-roof case or orchard-house with some heating in it was put up instead as a boundary. It was too large to devote entirely to peaches, but these, with the finer kinds of plums and the best varieties of pears, do splendidly in it. The heating of peach-cases costs only the initial cost of putting in the pipes; the heating required for a short time when the trees are in flower, and for a short time in autumn to ripen the wood, is easily applied without any extra tax on the ordinary heating apparatus.

There is a large variety of peaches now, and if one had only one long house with little heating and no means of forcing, one might, by a good selection of earliest, mid-season, and latest varieties, secure a supply of ripe fruit from the end of June until October.

Hale's Early is one of our best for early forcing. Stirling Castle is another old favourite for forcing. Royal George forces well too. Violette Hâtive is a very good certain cropper. Bellegarde is another good cropper. Grosse Mignonne and Noblesse are the two finest flavoured peaches. Walburton Admirable and Sea Eagle are the two best late peaches.

The following varieties of nectarines are good :—Precoce de Croncels, Lord Napier, Elruge, Humboldt Downton, Victoria, Pine Apple.

## THE PEAR AND THE PLUM.

Glass cases or glass coverings of some kind should be much more adopted than they are for growing the finer kinds of plums and pears in our cold northern districts.

I have had heavy crops of pears every year from pear-trees in pots grown in the following way :—About the end of February I placed fifty pot-pears in a late vinery, keeping a lot of ventilation on both top and front night and day. This constant air prevented the vines from starting, and at the same time the pear-trees opened flower, and the abundance of air helped them to set. They set abundantly, and I then took them out of the vinery, plunged them in a sunny place, and with feeding they grew fine crops. The trees were out of the vinery in good time to let it be started, and the trees were under glass during only the short time required to set the fruit ; in other words, to protect the blossom from frost.

The best varieties of gage-plums are worthy of a glass house or case in our northern climate. I have had very heavy crops of gage-plums by the following method :—Plant against a south wall. On top of the wall put a glass coping projecting twenty-one inches. Along the whole length of the outer edge of the coping fix an iron rod, on the rod a good quantity of rings, and to the rings attach a canvas curtain which reaches to the ground. The glass coping was a permanent fixture, the curtain was fixed up when the trees opened flower. The curtain was not allowed to cover the trees through the day, only at night to protect from frost; through the day it was tightly drawn together. Young plum-trees grow very much to wood, throwing up strong watery shoots. To counteract this I examined the roots, and often lifted the trees every autumn, cutting away strong roots, keeping the roots near the surface, and putting amongst the roots each time fresh fibrous loam. Doing this for a few years in succession made the trees very fibrous rooted and the wood of medium thickness clad all over with flower-spurs. Plum-trees in this state, and with good protection from frost, cannot fail to yield good crops even under unfavourable circumstances, and in this the skill of the gardener shows itself.

The best varieties of plums and pears are, however, worth a case or house. Heating with pipes is not required for these fruits unless in a very sunless season such as our last one. Heat in the pipes would, in the absence of sun, swell the fruit and ripen the wood. In addition to paying careful attention to the roots of the trees to make them fruitful, the plum requires disbudding and laying in yearly young wood, for it usually bears on the two-year-old wood, not on the one-year-old wood as in the case of the peach. If the laying-in of young wood is neglected for a few years in plum-trees, particularly the best kinds, the trees become just so many thick bare sticks.

The watering of borders, especially inside ones, must be carefully attended to, and, as in the case of the peach, one or two good waterings in winter are essential. Fly and scale are the two most troublesome insects to plums. The fly is easily kept in check with syringings of weak soapy water. A weak solution of paraffin kills the scale.

I would restrict the growing of pears under glass to a few really good useful sorts, and particularly to those varieties that come into use quite late. Beurre Rance is worth giving a good bit of glass-space to itself. It is one of our best late pears, but it comes to no good growing on the open wall in the North. It grows a large size under glass, and with enough of it can be used from January to March. Glout Morceau is worth growing under glass in the North for December and January. Nec Plus Meuris is another valuable late pear, and worth glass-room. Marie Louise and Doyenné du Comice are two of our finest pears, and in cold districts well worth growing under glass. Either horizontal or dwarf trained would do for back walls of houses, but I think the cordon-trained pears are most suited for growing under glass; they are more easily managed in the matter of the roots, and thereby kept more constantly fruitful than larger trees.

The following varieties of plums I have found to give very heavy crops, either under the glass cope projecting from the top of the wall I have described, or in a lean-to house, or a span-roofed orchard-house, without fire-heat:—Boulouf, Bryanston Green Gage, Coe's Golden Drop, Early Transparent Gage, Green Gage, Jefferson, Kirk's, Late Transparent, Reine Claude de Bavay, Stint. These are all plums of first-class quality and free bearing

under glass, and of course nothing but the best varieties of plums are worth going to the expense of putting glass over. In the southern counties of England, glass is not required even for these best varieties. Splendid crops are produced on open walls, and I have seen good crops on orchard-standards. If restricted to one or two varieties, I should grow Early Transparent, Jefferson, Kirk's, and Stint.

## THE APRICOT.

I knew of a good south wall covered with apricot-trees, and fairly fruitful considering they were in a poor soil. It was thought, however, that covering them with a glass case would improve the crop in every way, and a narrow lean-to house was put against the wall and over the trees, but the apricot-trees did not bear so well as they had done on the open wall, and after a few years the trees died out altogether, showing that closing them in a glass house does not suit them.

I belive a very successful way to grow the apricot under glass is the following:—Erect a structure of the nature of an open shed and roof it with glass. Make the roof a good width and of the same flatness as an open shed. The apricot-trees to be used should be standard-trained with long clean stems, long enough to reach from the ground to the top of the shed. The trees should be planted at the mouth of the shed, the roots would be in the open border. This procedure meets what seem to be the two important requirements of the apricot—the roots are in the open border, and the trees are fully exposed to the air, with sufficient glass to better ripen fruit and wood and make the fruit larger. The apricot does best on heavy soils, should be well surface-fed with manure, and requires abundant moisture at the roots. Apricots do well on the open wall in many parts. It is only in districts where they do not do on open walls that glass sheds or copings should be used. Some would say let us have the finest varieties, such as Moorpark, or none at all. I say in unfavourable districts grow such varieties as Breda and Kaisha. Owners of gardens will much appreciate these, when it is a choice between them and none at all. These latter are the hardiest and most free bearing of all apricots.

## THE FIG.

The cultivation of the fig under glass was, up to very recent years, generally considered a very secondary affair. The back of a vinery, or back of some house the front of which was devoted to the growth of other things considered then of more importance, was considered just the right place to plant fig-trees. I wish to say here that I have seen some splendid examples in different parts of the country of immense fig-trees on the back walls of vineries, giving large crops of very large figs, the borders for the roots in all cases being restricted to about a width of two feet. Well-grown ripe figs, however, have in recent years come to be considered our best and most to be desired fruit. It is said, from a gastric point of view, that a person may eat ripe green figs who could not eat any other fruit. We find, therefore, that in gardens where the fig formerly gave one crop of fruit in the year on the open walls, houses specially for growing the fig have been built; I instance one in such a very mild district as Fota, near Cork. And we need not wonder, for the fig does not require a high temperature, and if grown under glass in the desired temperature, it gives in the year two full crops of ripe fruit.

The form of house best adapted for early forcing is lean-to; for later crops the span-roof is best, as it gives the greater fruiting space. The roofs of the houses should be trellised in the same way as for vines, and the fig-trees trained all over the roof so as to ensure short-jointed well-ripened wood. In making borders for fig-houses, if the site is a cold clay subsoil, a concrete floor must be made, sloping to a drain running along the front of border if the house be a lean-to; or, if span-roofed, the drain should be under the pathway and the concrete floor sloping from both sides to the pathway. To have each tree growing in the most fruitful and favourable circumstances, instead of filling up the whole border with drainage as for vines, you must intersect the border with brick walls, dividing it up into as many spaces as you mean to plant trees. This restricts the root-space and prevents the roots of one tree growing into another, and thus you can control the roots of any tree you wish. These sections or root-spaces must be made in size according to the size of the tree to be

grown, or according to size of roof-space. I have seen a fig-tree covering the whole back wall of a very large vinery, and the roots confined to a space six feet long by two feet broad; fresh soil was put in each year, and with good manure waterings heavy crops were grown each year. The intersections being built, two tile-drains should be laid on the concrete of each compartment, and about eight or nine inches of broken stones laid over the whole floor for drainage, with fresh sods, grass-side down, laid all over stones.

What kind of soil do figs grow best in? The fig has a tendency in good rich soil to grow too gross wood. That does not ripen, and hence will not give fruit. A light soil well mixed with lime-rubbish is best. The depth of border for fig-trees should not be more than two feet, and in making a new border eighteen to twenty inches will be deep enough to begin with. The roots should be all on the surface of the border, and should get very frequently top-dressings of soil, bone-meal, and approved artificial manure. By this, in course of years, the border will get deeper, but the roots ever in the right direction keeping upward.

I will now treat of the raising of the young fig-trees and preparation for planting.

Raising plants from cuttings is the best method. Select for cuttings straight, short-jointed, well-ripened wood of the previous season. Each cutting should be eight or nine inches long with a strong terminal bud, and in detaching the cutting from the plant take with it an inch or two of the two-year-old wood. Insert the cuttings singly in four-inch pots, and plunge in a bottom-heat fairly strong, but the atmospheric temperature should not exceed 60°. This proper balancing of atmospheric and bottom-heat is very important. Should the atmospheric temperature be high the cuttings shoot into growth before making roots. It is better that they make roots first and the growth afterwards—sturdy and short-jointed. The time for putting in the cuttings is the middle of February, and they must be shaded until rooted. When four-inch pots are filled with roots, shift into six-inch pots, using turfy loam but no manure. The cuttings will grow away quickly now without bottom-heat. At this stage it is important to prepare your young plants with a good clean stem of twelve inches, otherwise the plants will

throw up suckers, and the trees will always remain a bunch of suckers. A clean stem of twelve inches with three buds at the top, one for leader and two for shoots right and left, should be your one-year-old plants. These are not considered the best for planting in the border. The best practice is to give another shift into an eight-inch pot in soil of a poor nature, and grow to the desired height, with a leading shoot and two side shoots again. Thus we have now two-year-old plants in rather small pots, with two tiers of horizontal shoots and a leader. The object in keeping them two years in pots is to get them into a fruitful condition.

The best time to plant figs is in the spring when they are about to start into growth, and although the two years or longer preparation of the plants may point to planting them in the open border with ball intact, I prefer to shake out the ball and to spread out the roots, keeping them very near the surface. I have seen fig-trees established in pots, the ball put into the border whole, with the result they grew almost none at all. The border before being planted should be made very firm. This makes the roots grow fibrous. A loose border makes the roots grow gross and go to the bottom of the border, and in turn makes the wood gross and unfruitful.

When a house is planted with young fig-trees comparatively small, there will be an abundance of light all over the house sufficient to admit of a number of fig-trees being grown in pots alongside the planted ones, and thus full use of the house will be made. Figs grown in pots give a good quantity of fruit. They require much attention in watering, and to be liberally supplied with manure-water. Fig-trees fruited in pots should, at the end of their fruiting season, that is in the autumn, be turned out of the pots, a good portion of the soil shaken out of the ball, any strong roots cut away, and then be repotted in good turfy soil mixed with lime-rubbish and some bone-meal. They should then stand in a cool house for winter. A top-dressing with a good artificial manure when they are growing will be beneficial.

On starting a fig-house keep the mean temperature 55°, raising through the day 10° more, or 15° with sun-heat. The temperature should be 60° at night when the trees have burst into growth, and there should be a corresponding increase of

temperature by day. When the season advances and less fire-heat is required the night temperature may be 60° or 70°. The leaves of the fig succumb more quickly than almost any other fruit-tree leaves under glass with a dry fire-heat atmosphere to red spider. Syringings and the preservation of a very moist atmosphere must be constantly attended to, and air should be given on all possible occasions through the day. I have observed that the fig when in full growth requires a great deal of water at the root, that is to say, if the soil is of the porous nature it should be. As to the pruning and general treatment of old-established fig-trees, pruning should be done in winter when the trees are dormant and do not bleed. During the summer, however, is the time to pinch and regulate the growth. Overcrowding of the branches must be guarded against. Lay in young growths, watching to keep the trees well furnished to the centre, and to give the young growth full light to ripen. Cut out old wood no longer fruitful. Pinching back young growths to three leaves makes fruitful spurs all over the tree. The first crop of figs is on the ripened wood of the previous summer, the second crop is on the wood which has grown along with the production of the first crop. The summer-pruning and pinching must, therefore, be done with a view to secure both of these. Some shoots should be allowed to grow to keep the tree furnished and take the place of bare branches worn out, and at the same time a considerable portion of the shoots should be bruised at the point when about five eyes long. Fig-trees in summer are too apt to get overcrowded with growth; this should be strictly guarded against. When the trees ripen and drop their leaves, the borders may be kept dry, but not too dry.

Figs growing in small allotted root-spaces to each tree will be benefited by taking out the width of a spade of soil all round the outer edge of the space right down to the bottom of the border and filling in again with fresh turfy loam mixed with lime-rubbish and bone-meal. Removing also the whole of the old surface of the border, and putting on bone-meal with a little artificial manure and a little fine-chopped turfy loam, will cause a quantity of new fibrous roots to develop. By repeating this yearly the trees will be kept just vigorous enough to make good short-jointed fruitful wood. Give manure-water and plenty of water when fruit is swelling, and you will get fruit of good size.

There is a great variety of figs, and out of about fifty varieties I have found the following the best:—

Brown Turkey, Negro Largo, Pinge de Mel, St. John's, White Ischia, White Marseilles, Black Ischia.

## THE STRAWBERRY.

To be successful with early forcing of strawberries, you must get runners early, grow them quickly on, and have good plants in the autumn with stout crowns well matured. In gardens where forced strawberries are grown in large quantities, plantations of strawberry-plants are now specially made for the purpose of getting early runners.

The plan adopted is:—In July, layer as many runners as are required in four-inch pots and prepare a south or warm border. At the beginning of September plant it with these now well-rooted runners taken out of the pots. Planting thus early the plants get well established before winter. The following May they will throw up flower-spikes. As soon as these show they should be all cut off; this will throw the whole growth of the plants into producing leaves and runners instead of fruit. Runners are got this way a fortnight earlier than from the older plantations, a matter of the greatest importance. The middle of June is a good time to begin preparing young plants for forcing. Several methods have been tried for the early rooting of runners, but the plan found to work best and which is most generally adopted is to fill clean two-and-a-half or three-inch pots with good rich soil—and a large number of these being filled in the potting shed can be conveyed on a handy spring wheel-barrow to the border of strawberries—then with trowel proceed to plunge the pots between the lines and place a runner on each pot, pressing it in with a stone the size of road-metal, and leave the stone on pot. The weather at this season is usually very dry, and so watering of runners must be daily looked to even although the pots are plunged. In about a fortnight or three weeks' time these little pots will be well filled with roots, and the transference into their fruiting-pots should be proceeded with forthwith. The middle of July is a good time to put them in the fruiting-pots.

Experiments have been tried in the past with different sized

pots for fruiting forced strawberries. Pots six inches in diameter are now considered the best for the whole quantity to be forced; seven-inch pots for the latest batches are considered to take less watering, but I am doubtful about it. Both six-inch and seven-inch when the season is advanced will require saucers, and six-inch with saucers will produce fruit quite as good as seven-inch pots. All the pots should be carefully washed and carefully crocked. Cover the crocks with moss, and over the moss sprinkle soot, which is a manure and a preventive against worms. Strawberries require a heavy loam, but this very often cannot be got. Get the best fibrous loam you can, chop up in small pieces, mix a six-inch potful of bone-meal to every barrowful of soil, and also add some fresh horse-droppings passed through a half-inch sieve. The soil and pots now being in readiness, take the young strawberry-plants carefully out of the three-inch pots, put them in the six-inch in such a way that the top of the three-inch ball will be half-an-inch below the rim of the six-inch; fill in the pack firmly round the ball, finishing by leaving quarter of an inch under the rim to hold water. The plants should be watered with a rose immediately after potting, and stood for a few days in a shady place where the full day's sun will not reach them; after this they should be stood in a warm sheltered place where the full sun reaches them. I have always found the plants grow better standing on boards, coal-ashes, or dry bottom, much more so than standing on the ground. Of course, wet and dry localities make a great difference in this; in a dry place on gravelly subsoil they will do well standing on the gravel walk; in a wet locality with damp, cold subsoil the plants do much better raised from the ground.

When the plants are growing they must stand sufficiently apart from one another to allow full development of the foliage, and if they show a tendency to develop several weak crowns to a pot, remove all but one to make a good strong crown. If the weather is dry through the autumn, they must be carefully looked to twice a day for watering, and when the roots reach the side of the pots, clear manure-water should be given them; soot-water being one of the best for strawberries. Keep the pots carefully weeded, and do not allow runners to get ahead on them. By the end of September the pots will be well filled with roots, and

the crowns well developed. Should the weather become cold and wet in October, the plants are better protected from it in some way, indeed put into their winter quarters.

A good place to put them for winter is in a peach-case or orchard-house, where they can remain undisturbed till well into spring. In the absence of these put them in cold-frames plunged in leaves to protect the pots from being cracked with the frost. Even in some large gardens, however, glass protection cannot be spared for them, and they are then built up in ridges, putting the pots on their sides, packing in amongst ashes or any material that will keep out the frost from cracking the pots. Care must always be taken that the roots do not get dry. I have seen a batch of strawberry-plants good in every way and splendidly prepared for early forcing, with fine ball crowns, yet having been allowed to get dry before starting to force, they never threw up flowers, and had to be thrown out after occupying bed and shelves for six weeks.

I do not know any crop that requires more watchful care than a very early batch of pots with ripe strawberries, and yet it gives more pleasure to succeed with them.

The strawberry-plants now prepared being all that could be desired for early forcing, that is with good crowns and pots full of roots, the next thing is how to begin the forcing. In most gardens there are no special houses for this. Pits, frames, peach-houses, and vineries must be used for them, and with this accommodation I have frequently picked a dish of ripe fruit in the latter end of February. The best place I have found for starting early batches of strawberry-plants is a brick-built pit, heated with a flow and return, and deep enough to be filled nearly four feet with leaves. No dung should be used; the leaves alone give the gentle bottom-heat required—namely, about 75°. If even a little dung be used with the leaves I find it a failure. The bed being duly prepared before, the latter end of November is the earliest time to plunge a batch of plants in the leaves. The heat of the leaves will be sufficient for the first fortnight, then heat may be put in the pipes to keep a temperature of 50° to 55° mean, 10° more by day with aid of sun. Keep steady at that until they throw up their flower-trusses, then they must be removed to a shelf in a house near the glass, and I have found

the best success at that period of very short day by keeping the mean temperature not less than 60°. The time of removal from pit to shelf is suitable for giving a little top-dressing to the surface of pots with artificial manure mixed either with soil or sand. Some prefer to give the top-dressing when putting them in at the beginning. This top-dressing is essential. It makes fine foliage, not liable to red spider, and helps the vigour of flower-spike. The plants being now on the shelf and in flower, to get them to set well the air must not be close and stagnant; as a rule, however, at that cold season in most of our houses sufficient air gets in at not too close places.

After the fruit is set they may be shifted to a higher temperature or the temperature increased, but try and give what air you can. You must now feed the plants to get good-sized fruit, not strong doses but weak and often. Soot-water is one of the best for pot-strawberries. A change of manure-water is best.

A good plan for feeding strawberries, especially as the season advances and pots on shelves dry up much quicker, is to place well enriched soil underneath the pots. This may be done in three ways:—Firstly, a little square sod sprinkled with artificial manure may be put under the pot; secondly, fill a saucer with a hole in bottom with a soil mixed with manure, and place the pot upon it; thirdly, half fill a six-inch pot with enriched soil, and stand the pot in it. In all three cases the soil under the pot-plant gets filled with roots and helps the size of the fruit very much. It is a mistake to leave more fruit on a pot than will swell to a good size. What you grow strawberries in pots for is dessert, and they should be a fair size.

Mildew, green fly, and red spider are the three things that injure most the foliage of strawberries under glass, and my experience leads me to say (we force 6000 pots annually) that if the plants are properly attended to at the roots with water and the manures best adapted to them, you will have very little, if any, of these pests on your plants. I have proved Veltha to be a certain preventive for mildew, and also a powerful manure for the plants. The fruit should be supported to prevent hanging over the pot-edge.

Steven's Wonder, Auguste Nicaise, and John Ruskin are the kinds I found best for very early forcing. Scarlet Queen, Royal

Sovereign, and Leader are best for later. I am fond of President too. After the strawberries are forced put them in some cold frame, and later on plant out; they will throw a very large crop the following year, then clear them out.

A word as to packing:—Line the box with wood-wool and cotton-wool, put strawberry-leaf or lime-tree-leaf round each fruit, place them husk-end down in a single layer in the box, and pack close enough to prevent shaking. I prefer wood-boxes to tin-boxes.

## THE PINE-APPLE.

The first consideration for the cultivation of pine-apples is the house or structure for growing them in with least trouble and expense. I have seen during the past thirty years a good many different ways and structures for growing pine-apples throughout the United Kingdom, but have not seen one so good in every way as the pinery at Dalkeith. It may be described as a low three-quarter span-roof house seven feet high at the apex or span, and just wide enough for a bed to hold three lines of pine-apple plants in fruiting-pots, and a path two and a half feet wide running at the bottom of the back wall. The bed in which the pine-pots are plunged has a bottom-heat chamber underneath heated with hot-water pipes. The floor of the bed over the heated chamber consists of thickish stone flags. The reason for using such flags is that they retain heat better than a thinner material would do, and fluctuations in heating from the pipes underneath being too cold or too hot are not so readily felt, and therefore a steady bottom-heat is kept to the pines—a matter of great importance. Tan bark is used in the bed for plunging, and this house has always a very neat and clean appearance inside, a great contrast to the insides of pineries where dung and leaves are used or where the planting-out system is adopted. In some large gardens span-roofed houses are used for pine-growing, but they require much more heating, and that is a matter of great importance in our long, cold, sunless winters, and I think pines get drawn in span-houses. The nearer the pines are to the roof the better. Stubby, thick-necked pine-plants alone produce good fruit.

The structure best adapted for growing young pine-plants from suckers onwards as successionals is a brick-built pit with top and bottom-heat. The temperature in winter does not require to be high, and these pits are easily heated, and in case of very hard weather frigidoms can be run over the lights.

Pine-growing is becoming limited to a very few places amongst British gardens. It is expensive, especially with such dear fuel as we have been having lately, and the pine-apples now imported are abundant in quantity, of fine size and looks, and very cheap; they are, however, very deficient in flavour when compared with our home-grown ones. The public generally are not good judges of first-rate fruit; this is very noticeable in the quantities of good-looking but poor-flavoured grapes sold. I think, therefore, the wealthy leaders of society who wish the best of everything will want the best grown British pines and British hot-house fruit, as being superior to anything else.

The great decrease in British pine-growing has also restricted the varieties grown to what are the best, and they number only three or four. The Queen is the best flavoured pine, but can only be grown for summer fruit, that is from May until October —it is no good for winter. It takes the least room, growing in smaller pots than others, is of a dwarf habit, a free grower, certain fruiter, comes quick to maturity, and has a beautiful golden colour.

The smooth-leaved Cayenne is the best winter pine, that is for producing fruit from October until May. The fruit is larger and the plant is larger, requiring a pot one-and-a-half to two inches more in diameter than the Queen.

Black Jamaica is the finest-flavoured winter pine. It grows strong; fruit rather small, and of a dull colour. This variety is always much appreciated in dessert.

Charlotte Rothschild is the next best winter pine, and is rather taller-growing than the others, and has fruit similar to Cayenne.

To keep up a succession of pines all the year round, these varieties are sufficient.

Pines have been grown in very varied soils. I have seen a large number grown in nothing but peat, I think because it was the most convenient, but the fruit was very small and the plants grew

to leaf and did not fruit well. Some think heavy clay is the best. It will be found, however, that where any good pine-growing is done, the soil is of rather a light nature and fibrous. The soil I prefer for pines is an old fibrous sod, neither too light nor too heavy, and to each barrowful of soil I add an eight-inch potful of bone-meal. This is really all the mixture that is required for pines. If the soil is clay, or of a heavy retentive nature, fine lime-rubbish must be added to keep the soil open.

Suckers and crowns are the two sources from which pine-plants are raised. The crowns are only taken when suckers cannot be had. Suckers make far the strongest and best plants. There is never any difficulty getting plenty suckers from Queen-pines in summer and autumn, but there is often a difficulty in getting enough suckers from smooth Cayennes. With the latter it will be found necessary often to put the old stools, after the fruit is cut, in some warm pit to grow and produce suckers. It is a great mistake to remove the suckers from the old plants before they have grown to a good size; good suckers always make the best and quickest plants.

I shall treat of Queen-pine suckers first. Plenty of them should be had in August and September. Cut them clean at the base and remove the bottom leaves. Six-inch pots will be large enough for the most of them, seven or eight inch may be used for larger suckers. The pots should be well cleaned and crocked; the suckers should be placed well down in the pot; the soil, not of too wet and pasty a nature, should be firmed well with a blunt stick, leaving sufficient room under the rim of the pot to hold water. The pots should then be plunged in a handy succession pit with bottom-heat of 90°. Put them wide enough apart to prevent drawing and to ensure the essential stubby growth from the first. Shading and dewing will be necessary until they have made roots, after that discontinue shading and give enough water to water the whole ball. Give a good deal of air at this time to make them sturdy and prepared for winter. The temperature, say in September, may be 65°, but as November approaches reduce to 55° to 60° according to weather; the bottom-heat in winter should also be reduced; 75° keeps the roots nice and healthy.

These rooted suckers should now from the middle of November

till the middle of February be kept at rest, and the best temperature for that is 55° atmospheric, 75° bottom-heat; keep the plants dry at root, almost no watering at the roots will be required, and no moisture in the air.

From the middle to the end of February the suckers should show white healthy roots all round the sides of the pots, and be ready for a shift. I practise putting them in their fruiting-pots at once. Ten-inch is large enough for Queens. Let the full number required be thoroughly cleaned and well crocked, get all the soil prepared, and have everything in readiness before beginning to pot. The plants should be well watered before repotting. Fresh tan should be at hand too, for the best way to treat the plunging material is to throw the new tan on top of the old and then to turn them over together and thoroughly mix them with forks; this mixing of old and new tan prevents the bottom-heat rising too high. Everything being now ready, the transference into fruiting-pots and the plunging of the plants in the bed where they are to grow may proceed together. The soil for potting should not be of a wet but rather of a dry fibrous nature, and should be well rammed with a blunt stick round the ball. The plants should be plunged two feet apart every way. The bottom-heat should not be allowed to exceed 90°; if it does, move the plants from side to side, and thus make an opening all round the pot. For the first fortnight after potting, the plants will not require much water, if any, and the weather still being cold a mean temperature of 60° will do. These plants will now be grown on all summer. When the weather gets warmer a mean temperature of 70° should be maintained, shutting up in the afternoon at 90°, and giving them a syringe. By the end of August the plants should have well filled the pots with roots, and the object now is to preserve the roots and plants in a healthy state all winter. The plants must be sparingly watered in September and liberally given air in good weather; at the end of the month they should be at rest in a dry atmosphere with a temperature of 55° to 60° and a bottom-heat of 75° to 80°. They will need almost no water from October until January.

The pine-plants being rested safely until January are called fruiting plants, and now, say middle of January, should be removed to their fruiting quarters. Fresh tan must be added

and mixed as before with the old, and the plants plunged in it two feet apart. The plants must now get water to moisten the whole ball, adding to it manure-water and guano or artificial manure. The temperature should be 60° to 65° at night and 70° through the day with fire-heat, 80° with sun. The moisture must be increased by damping paths, walls, etc. Care at this season must be taken in watering not to let any plants get too wet. As the season advances a temperature of 70° mean should be maintained, and shutting up at 85° or 90° may be practised. The plants will throw up the young fruit in March and come into flower, and during the flowering period the house may be kept drier and there should be no syringing. Flowering being past, give more moisture and shut up with high temperatures from sun-heat. During May the fruit will swell rapidly. At the beginning of June the fruit will change colour, when more air and less watering and moisture will be requred; attention must, however, always be paid to the keeping up of the bottom-heat.

To maintain a supply of ripe pines all the year round suckers must be taken and plants potted on at frequent intervals. Three lots of Queens will be required for summer, and two lots of smooth-leaved Cayenne for winter. Cayennes are much shyer of throwing suckers than Queens. Get all the suckers you can by October, and if you have not enough for your purpose use crowns in spring. In the month of March get what suckers you can also. These two lots will give the fruit for the winter and spring months. The method of growing the Cayenne from suckers until it has ripened its fruit is the same as for the Queen, excepting that the Cayenne, being a stronger grower, requires a pot two inches larger for fruiting in. The Cayennes being the winter-fruiters, you keep them growing when the Queens are resting; that is, as I have said, you lower the temperature for the Queens and keep them drier in winter. The Cayennes you keep at a mean night temperature of 60° to 65° in winter and 10° higher through the day. Give them sufficient water and manure-water to keep them growing and to swell their fruit.

To have ripe pines all the year round should not be attempted unless there are good pineries and good accommodation for growing them; and if there are good pineries there is no more trouble in producing pines in winter than in summer. I have

only seen pines grown on the planted-out system at one place, namely Frogmore. They grow and fruit right enough, but the pits all opening and worked from the outside with sashes seemed to me wide, unhandy things to work. The pot-system in a neither very wide nor high pinery is the best, and where the pinery is an up-to-date structure pine-growing is simplicity itself.

Scale and bug are the two insect-pests that infest pines, and the only way to effectually banish these is to destroy the plants and begin with a clean fresh stock from the suckers onwards.

# Observations on the Girth-increase of Trees in the Royal Botanic Garden, Edinburgh.

BY

DAVID CHRISTISON, M.D.

## PART II.—CONIFERÆ.

### CONTENTS.

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THE Coniferæ under observation have not thriven so well as the Deciduous trees, not from a faulty selection, but owing to general causes affecting all of the tribe in the Garden. Poverty or incompatibility of soil may be the main cause, but not improbably increasing influences of town atmosphere contribute to the evil. That the nature of the soil is not the only cause is indicated by some pines having attained a size and beauty, when our observations began more than twenty years ago, such as none of the younger trees now coming forward give promise of reaching; and that the Coniferæ are extremely sensitive to Edinburgh atmosphere, so that they might possibly be affected even by the present comparatively slight town-surroundings, seems proved by the almost total absence of pines in the city gardens, and the miserable appearance of the few that are to be seen. Another contributory cause, in some of the pines under observation, has been overcrowding in the Pinetum, which, owing to the stress of more necessary work in rearranging the Gardens of late years, could not be dealt with in time to prevent injury.

The only species that has thriven well in the past, and continues to thrive well still, is the yew, but not a few other species have fared not badly up to and from the 15th to the 25th year of life, some individual trees to even a considerably greater age. To these, therefore, I shall mainly confine my attention, beginning, as in the Deciduous class, with the history of the species separately, although, unfortunately, except with a few, it is not possible to follow them out in the same manner, tracing the old trees from decade to decade and comparing them with younger sets in the second decade, because nearly all the Coniferæ of the first decade disappeared or became ineligible near or soon after the expiry of that period, and because there was no such difference in age between the sets in the Coniferæ as in the Deciduous class.

# I. ANNUAL RESULTS.

## A. General History of the Species separately.

### PINUS EXCELSA.

| No. in List. | Girth at 1st Observation. | 1887. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | Total. | Ann. Av. | Girth at last. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2·60 | ·90 | ·90 | 1·20 | 1·20 | 1·20 | 1·25 | 1·15 | ·90 | 1·20 | 1·05 | 10·95 | 1·09 | 14·90 |
| 11 | 3·70 | .. | .. | 1·00 | 1·30 | 1·00 | 1·35 | 1·00 | 1·25 | 1·30 | 1·40 | 9·60 | 1·20 | 14·50 |

Two older trees of this species stood in the first decade on the former terrace in front of the hot-houses. No. 24, much damaged by frost in 1878, became stunted, and the rate of girth-increase was only 0·24. In the second decade it declined to 0·18, and the tree when cut down in 1894 girthed only 34 inches. No. 26, taller and better proportioned, but rather scraggy, had a rate of 0·50 in the first decade, and kept it up in the second, but was not thought worth transplanting when the terrace was removed. It attained a girth of 40 inches.

Two infant trees, Nos. 2 and 3, were selected in 1887; but No. 3, choked by its neighbours, proved useless. Its rate was only 0·38. That of No. 2 was 1·09, the range being only ·90 to 1·25. No. 11, when an infant, had been transplanted to the "Triangle," and quite recovered in 1889. It continued to thrive with a rate of 1·20 for eight years when in 1897 it was again transplanted to the Pinetum, west of the Rock Garden, from the effects of which it had not recovered in 1900. It had the moderate range of 1·00 to 1·40 during the eight years.

### PINUS LARICIO.

In 1887 this was one of the largest pines in the Garden, with a girth of 5 feet 8 inches, and it had grown at the rate of 0·41 in the previous decade; in the next nine years the rate fell to 0·35, and in 1896 it was cut down, while still sightly enough, with a girth of 6 feet and a height of 60 feet.

The other species of *Pinus* did so badly that they may be very briefly noticed.

*Pinus sylvestris.* The failure in this is remarkable, because the species can thrive in the Garden, as one tree in the Arboretum was 7 feet 10 inches in girth when cut down a few years ago. None now living are much over 4 feet. They have poor heads, and they have ceased to increase in girth.

*Pinus Murrayana.* The best of two had a rate of 0·67 for ten years, and was cut down in 1897 when only 20 inches in girth and unsightly.

*Pinus Pinaster*, a handsome infant, increased at the rate of 0·80 for seven years, but for the next four it fell to 0·55, and the tree is now a scraggy weed.

*Pinus Lambertiana* and *P. Cembra.* Two of each also proved utter failures.

## ABIES DOUGLASII.

In my Paper of 1888 a full acount is given of the first tree of the species in the Garden, the progenitor of all that are now in it. In 1837 it girthed 4 inches at 4½ feet above ground. For the next 37 years its rate was fully an inch and a half, and in 1878, when nearly 50 years old, the tree was nearly 5½ feet in girth and crowded to the ground with branches. After the severe frost of 1879 it began to lose its handsome appearance, the increase never exceeded 0·40, and it was cut down in 1887 when 67 inches in girth, 54 feet in height, and according to the rings 55 years old. None of its descendants have at all equalled, or give promise of equalling it.

| No. | Girth, 1st Obs'n. | 1887. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | Total. | Ann. Av. | Girth last Obs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 66 | 7·90 | .. | .. | 1·20 | 1·25 | 1·10 | 1·10 | 1·45 | 1·00 | ·95 | 1·05 | .. | 9·10 | 1·14 | 17·05 |
| 6 | 4·35 | ·95 | ·80 | ·40 | ·55 | ·65 | 1·00 | 1·25 | ·90 | 1·30 | 1·15 | ·85 | 9·80 | ·89 | 14·25 |
| | 7·80 | .. | .. | 1·20 | 1·20 | 1·05 | 1·10 | 1·10 | 1·30 | 1·20 | ·95 | ·75 | 9·85 | 1·10 | 17·65 |

None of these has ever recorded an inch and a half in a single year, a rate which their parent maintained for 37 years. No. 99 already has a scraggy look; No. 6 looks only moderately well; and No. 66 has been transplanted, so that it remains to be proved how it will do.

## ABIES LOWIANA.

Of two specimens observed in the first decade one perished almost immediately. The other, No. 31, girthed 15 inches in 1876, and its annual average was 1·11 for 12 years, with a maximum of 1·40, but it then rapidly degenerated and was cut down in 1888, girthing 27 inches.

| No. | Girth. | 1887. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | Total. | Av. | Final Girth |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 4·65 | 1·95 | 1·50 | 1·85 | 1·90 | 1·65 | 1·70 | 1·85 | 1·50 | 1·05 | 1·20 | 16·15 | 1·61 | 20·85 |
| 92 | 3·95 | 1·95 | 1·65 | ·30 | 1·00 | 1·00 | 1·80 | 2·60 | 1·75 | 2·30 | 2·80 | 17·15 | 1·71 | 21·15 |

The two younger trees, Nos. 8, 92, show a better rate, up to a girth, however, not much above that of No. 31 when it began to fail. Their conduct, too, has been erratic. No. 92 had the high average rate of 2·22 for the five years 1892–96, but next year it dropped to ·95, and the tree looked so ill that it was cut down. In No. 8 the rate fell off from a ten years' average of 1·61 to 1·12 in 1896 and 1897. It was then transplanted. The range in No. 8 was 1·05 to 1·95, but in No. 92 was no less than ·30 to 2·80. The remarkable minimum of ·30 happened in 1889 from some unknown cause which did not affect No. 8.

## ABIES GRANDIS.

| No. | Girth. | 1887. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | Total. | Ann. Av. | Final Girth. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 91 | 3·00 | 1·25 | 1·15 | 1·65 | 1·25 | 1·60 | 2·10 | 2·50 | 2·25 | 1·85 | 1·95 | 1·65 | 19·20 | 1·74 | 22·20 |

In No. 91 the rate rose prettily steadily from infancy to a maximum of 2·50 in 1893, and although it declined to 1·65 in 1897 the tree is still one of the most thickly-clothed pines in the Garden. The increments were at first taken 2 feet above ground, and the points were raised to four and then to six feet, as the tree grew. The measurements in the Table are at 2 feet; but as it is a matter of some interest, I subjoin a Table of the rates at all three points for the four years 1893–96, showing that there was no great difference at the three points. The tree was well

clothed with branches between all the points. The general results to 1899 are placed at the end of the Table. They show that for the last three years the increase at the three points was all but identical.

| Girth. | | Increments. | | | | | | Girth. | Inc. for 3 more years. | Total Inc. for 7 years. | Av. | Girth. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1892. | | 1893. | 1894. | 1895. | 1896. | Total. | Ann. Av. | 1896. | | | | 1899. |
| At 2 ft., | 12·65 | 2·50 | 2·25 | 1·85 | 1·95 | 8·55 | 2·14 | 20·60 | 4·55 | 13·10 | 1·87 | 25·15 |
| At 4 ft., | 7·75 | .30 | 2·05 | 1·50 | 1.75 | 7·60 | 1·90 | 15·35 | 4·40 | 12·00 | 1·71 | 19·75 |
| At 6 ft., | 6·65 | 2·25 | 2·10 | 1·60 | 1·80 | 7·75 | 1·94 | 14·30 | 4·50 | 12·25 | 1·75 | 18·80 |

## ABIES HOOKERIANA.

| No. | Girth. | 1887. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | Total. | Ann. Av. | Girth. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 9·00 | ·60 | ·60 | ·70 | ·55 | ·50 | · | ·55 | ·50 | ·55 | ·50 | ·45 | 6·00 | 0·54 | 15·45 |

This shrub-like tree grew at a somewhat better rate for the first three years, when overcrowded, than afterwards when opened up. It has suffered from pressure on one side, but is generally well clothed. The range has been from ·45 to ·70, but for the last seven years it was only ·45 to ·55.

## SEQUOIA GIGANTEA.

| No. | Annual Inc. 1st Decade. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | Total. | Ann. Av. | Girth Last Obs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | ·81 | ·65 | ·70 | ·85 | ·80 | ·75 | ·90 | .. | .. | .. | .. | 4·65 | ·76 | 36·70 |
| 27 | 1·41 | ·90 | ·70 | 1·00 | 1·00 | ·80 | 1·50 | .. | .. | .. | .. | 5·90 | ·98 | 44·00 |
| 1 | 1·37 | 1·35 | ·90 | 1·25 | 1·25 | ·90 | ·95 | ·90 | ·65 | ·95 | 45 | 9·55 | ·96 | 42·25 |
| 2 | 1·28 | 1·05 | ·90 | 1·05 | ·85 | ·70 | ·90 | .. | .. | .. | .. | 5·45 | ·90 | 42·10 |

All these trees—Nos. 25, 27, standing free on the former terrace, Nos. 1, 2 in a small grove of the species—in 1878, when from 18 to 24 inches in girth, were symmetrically clothed and crowded with branches to the ground; but they soon began to thin and

to acquire the disproportionate thickness of stem below and sinuous top characteristic of all the species in the Garden past infancy. These faults progressed with a diminution in the rate of girth increase respectively, from ·81, 1·41, 1·37 and 1·28 in the first decade to ·76, ·98, 1·10 and ·90 in the first six years of the second. Three were then cut down, and No. 1, the survivor, now standing clear by the thinning of the grove, has not benefited by the change, as its rate has still further diminished—from 1·10 to ·74 in the last four years.

## ARAUCARIA IMBRICATA.

The best of several of the species observed in the first decade had a rate of 0·70 and attained a girth of twenty inches, but like all the others of its time in the Garden it had suffered seriously from the frost of 1860. Gradually deteriorating, it was cut down in 1887.

| No. | Girth. | 1887. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | Total. | Ann. Av. | Girth. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 64 | 7·25 | ·65 | ·60 | ·35 | ·55 | ·55 | ·60 | ·50 | ·75 | ·40 | ·50 | ·30 | 5·75 | ·52 | 12·70 |
| 65 | 14·45 | ·60 | ·60 | ·55 | ·65 | ·65 | ·60 | ·70 | ·75 | ·50 | ·65 | ·70 | 6·95 | ·63 | 22·00 |

Nos. 64, 65, selected in 1887, grew in a small grove of the species, unlike the earlier tree, which stood free on the former terrace. They look healthy though not close-branched, and No. 64 is overshadowed by 65, which may account for its inferior rate. No. 65, standing at a corner, is comparatively free. The range of No. 64 was ·30 to ·75; that of 65 only ·50 to ·75.

## CEDRUS AFRICANA.

| No. | Annual Inc. 1st Decade. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | Total. | Ann. Av. | Girth Last Obs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 39 | 1·51 | 1·30 | 1·20 | 1·30 | 1·20 | 1·20 | 1·50 | 1·25 | 1.10 | ·50 | ·50 | 11·05 | 1·10 | 53·55 |

No. 39 was very handsome and densely crowded with branches, and girthed two feet in 1878, but by the end of the first decade

the branches were rather sparse, and this fault has become more prominent since. The rate, 1·51 in the first decade, fell to 1·10 in the second, and as in the last two years it was only ·50 the tree would seem to have passed its prime when only 4½ ft. in girth.

## CEDRUS DEODARA.

| No. | Av. Rate, 1st Decade. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | Total. | Ann. Av. | Girth Last Obs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | ·88 | ·90 | 1·00 | 1·00 | ·85 | ·55 | ·80 | ·65 | ·30 | ·85 | ·50 | 7·40 | ·74 | 42·00 |
| 30 | ·60 | ·50 | ·65 | ·75 | ·35 | ·45 | ·55 | ·60 | ·15 | ·50 | ·30 | 4·80 | ·48 | 74·80 |
| 1 | 1·02 | 1·15 | ·30 | ·75 | ·80 | ·40 | ·55 | ·90 | ·20 | ·80 | ·15 | 6·00 | ·60 | 30·35 |
| 2 | 1·06 | 1·25 | 1·20 | 1·10 | ·85 | ·80 | 1·10 | ·80 | ·70 | ·70 | ·20 | 8·70 | ·87 | 35·25 |

No. 30 was a fine tree, nearly five and a half feet in girth in 1878, but soon got thin at the top and assumed, gradually, a rather stunted look. Its rate in the first decade was ·60. In the second it fell to ·48, with further degeneracy in the aspect of the tree. It has now the respectable girth of a trifle upwards of six feet. The much younger No. 29 has shown the same faults, and its rate has fallen from ·88 to ·74, the girth in 1897 being only three and a half feet. Both of these grew free, but Nos. 1, 2, have always been in the middle of a rather dense grove of their species. They are both still shapely, but their rates have fallen off from 1·02 and 1·06 in the first decade to 0·60 and 0·87 in the second.

## LARIX EUROPŒA.

Two young larches were selected in 1887 and looked well for some years; but one, after growing at the rate of 1·31 for seven years, became diseased and died in 1895. The other, in apparent health for three years with a rate of 1·03, rapidly degenerated, its rate falling to ·30 in the last seven years, and was cut down in 1898.

[TABLE.

TAXUS BACCATA.

| No. | Annual Av., 1st Decade. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | Total. | Ann. Av. | Girth. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 41 | ·47 | ·40 | ·60 | ·40 | ·55 | ·45 | ·45 | ·55 | ·40 | ·55 | ·20 | 4.55 | ·45 | 78·85 |
| 42 | ·26 | ·20 | ·30 | ·35 | ·30 | ·30 | · 5 | ·40 | ·15 | ·20 | ·05 | 2·30 | ·23 | 39·05 |
| 48 | ·48 | ·60 | ·30 | ·55 | ·45 | ·40 | ·50 | .. | .. | .. | .. | 2·80 | ·46 | 44·80 |
| 49 | ·45 | ·45 | ·45 | ·55 | ·35 | ·40 | ·55 | ·45 | ·25 | ·50 | ·25 | 4·20 | ·42 | 32·25 |
| 50 | ·37 | ·35 | ·30 | ·25 | ·25 | ·30 | ·25 | ·45 | ·35 | .. | .. | 2·50 | ·31 | 39·15 |
| 53 | ·25 | ·10 | ·30 | ·30 | ·25 | ·10 | ·35 | ·20 | ·20 | ·00 | ·05 | 1·85 | ·18 | 36·05 |

In my Paper of 1888 the history of No. 41 is fully given. Traditionally, an age of at least 213 or possibly 260 years is assigned to it, but the observations show that its rate has been nearly half an inch for the last twenty years, and taking the same rate for its whole life, and it is not likely to have been less, the age would be reduced to 170 years, with a girth of nearly six and a half feet. The rates in the two decades are nearly the same, and would have been still nearer but for the sudden drop in 1897 to ·20. This seems to have been due to the transplantation of trees around, which formerly closely sheltered it, and resulted also in a sickly look, which has not yet (spring, 1899) disappeared ; but as in that year it once more grew ·40, or nearly its average, it is to be hoped it will again prosper.

No. 48, an equally vigorous grower, died in 1894 from having its roots pruned in preparation for transplantation. No. 50, always rather weakly, was cut down in 1896. The three survivors, Nos. 42, 49, 53, all fell off, but not much, in the second decade. Although looking equally vigorous, and not differing much in size, their rates in the second decade varied as much as from ·18 to ·44.

Nos. 48, 49, 50, were known to be 77 years old in 1896, and allowing 7 years for growth to the measuring point, their life-rates have been ·68, ·45, and ·57, and the girths attained were 44, 32, and 36 inches.

## CUPRESSUS LAWSONIANA.

| No. | Girth. | 1887. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | Total. | Annual Av. | Girth. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 24·50 | ·40 | ·35 | ·45 | ·60 | ·50 | ·80 | ·80 | ·85 | 4·75 | ·59 | 29·35 |
| 10 | 22·20 | ·40 | ·20 | ·50 | ·70 | ·55 | ·55 | ·65 | ·85 | 4·40 | ·55 | 26·60 |

These cypresses were fairly handsome and grew at a rather increasing rate, averaging rather more than half an inch for the eight years, and above three-quarters of an inch for the last three, when, being badly injured by frost, they were cut down.

## THUJA GIGANTEA.

| No. | Girth. | 1887. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | Total. | Ann. Av. | Girth. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 20·80 | ·50 | ·70 | 1·15 | 1·10 | ·65 | ·80 | ·85 | ·60 | 6·35 | ·79 | 27·15 |
| 13 | 9·90 | ·50 | ·80 | ·70 | ·60 | ·40 | ·60 | ·55 | ·45 | 4·60 | ·57 | 14·50 |

The larger of the two, standing close together, had much the better rate. Both were handsome, when they suddenly failed in 1894, ceased to increase for the next two years, and were cut down in 1897.

## RETINOSPORA OBTUSA.

| No. | Girth. | 1887. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | Total. | Ann. Av. | Girth. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 4·30 | ·45 | ·25 | ·60 | ·60 | ·40 | ·65 | ·55 | ·60 | .. | 4·10 | ·51 | 8·40 |
| 90 | 3·05 | ·45 | ·20 | ·10 | ·10 | ·20 | ·20 | ·50 | ·50 | ·50 | 2·75 | ·31 | 5·80 |
| 15 | 9·60 | .. | .. | .. | ·30 | ·25 | ·70 | ·65 | .. | .. | 1·90 | ·47 | 11·50 |

The results in these are little reliable. Nos. 15, 90, became scraggy and were cut down as not worth transplantation, and No. 14, four years after transplantation, has scarcely added to its girth and looks unhealthy.

## B. Aggregate Annual Results.

I shall now give in a series of Tables some of the General Results of the Annual Observations on the Coniferæ.

### *a.* COMPARISON OF THE BEST SINGLE TREES OF 10 SPECIES IN TWO PERIODS OF FIVE YEARS EACH, 1887–91 AND 1892–96.

#### I. TREES IN WHICH THE GIRTH-INCREASE DIMINISHED IN THE SECOND PERIOD.

| No. in List. | Species. | Average Annual Increase. | | Girth. |
|---|---|---|---|---|
| | | 1887-91. | 1891-96. | 1896. |
| | | | | In. |
| 8 | Abies Lowiana - - - - | 1·78 | 1·48 | 20·80 |
| 66 | ,, Douglasii - - - - | 1·18 | 1·11 | 17·05 |
| 24 | ,, Hookeriana - - - | ·59 | ·52 | 15·00 |
| 1 | Sequoia gigantea - - - | 1·16 | ·87 | 41·80 |
| 2 | Cedrus Deodara - - - - | 1·07 | ·82 | 35·05 |
| 39 | ,, africana - - - - | 1·26 | 1·11 | 53·05 |
| 49 | Taxus baccata - - - - | ·46 | ·43 | 32·00 |
| | | 7·50 | 6·34 | |

It is shown in this Table that there was a marked falling off in *Sequoia*, *Cedrus Deodara*, and *Abies Lowiana*, at girths of 42, 35, and 21 inches, a less marked decline in *Cedrus africana* and *Abies Hookeriana* at girths of 53 and 15 inches, while *Abies Douglasii* and *Taxus* showed a very slight loss at girths of 17 and 32 in.

2. TREES IN WHICH THE GIRTH-INCREASE INCREASED IN THE SECOND PERIOD.

| No. in List. | Species. | Average Annual Increase. | | Girth. |
|---|---|---|---|---|
| | | 1887-91. | 1891-96. | 1896. |
| 91 | Abies grandis - - - - | 1·49 | 2·13 | 20·55 |
| 2 | Pinus excelsa - - - - | 1·08 | 1·11 | 14·90 |
| 65 | Araucaria imbricata - - - | ·61 | ·64 | 21·30 |
| | | 3·18 | 3·88 | |

In this Table only *Abies grandis* shows a very marked increase in the second period, up to a girth of 20 inches, while in *Pinus excelsa* and *Araucaria imbricata* the difference is little appreciable at girths of 15 and 21 inches.

In the aggregates the loss in average annual increase in seven species was 1·16 in., and the gain in three was ·70; the nett loss being thus ·46.

*b.* RANGE OF THE AGGREGATE ANNUAL GIRTH-INCREASE.

The range of the 19 Coniferæ of 9 species under observation in the first decade, 1878-87, was very great, as shown below, being from 9·60 to 16·60 inches in the whole, and from 5·03 to 8·27 taking species averages. As fully detailed in former Papers, the maximum, 8·27, was in 1878, and was followed by a decline in the three eminently unfavourable succeeding years to 6·16, but the minimum, 5·03, was not reached, after a rally in 1882, till 1883, and after a second rally for two years a third fall took place in 1887 nearly to the minimum.

| 1878. | 1879. | 1880. | 1881. | 1882. | 1883. | 1884. | 1885. | 1886. | 1887. |
|---|---|---|---|---|---|---|---|---|---|
| 8·27 | 6·45 | 7·05 | 6·16 | 7·05 | 5·03 | 6·41 | 6·93 | 6·68 | 5·80 |

In this decade-list we can see distinct evidence of a prolonged depression after the three bad seasons. The standard of 1878 was never again nearly reached, and after some fluctuations the final year was not far off the minimum. A detailed inqury shows that five species, *Pinus excelsa*, *Abies Douglasii*, *A. Lowiana*, *Pinus sylvestris*, and *Araucaria imbricata* had their girth-increase

permanently diminished after the three bad seasons; that two, *Cedrus Deodara* and *Taxus baccata*, were affected, but not permanently; and that two, *Cedrus africana* and *Pinus austriaca*, were unaffected.

In the remarkable and unaccountable second depression of 1883, in which the Deciduous trees were nearly or quite unaffected, all the deodars (4), all the sequoias (4), and all the other pinaceæ except the yew had a diminished increase.

Unfortunately, as most of the trees in this list completely failed early in the second decade, it is not in my power to give a Table of comparative results for the same trees in the two periods. The most I can do is to give the results of a new set, including a few of the old ones, in Table IX., comprising 17 trees of ten species.

Here the range proves to be actually greater than in the set of the first decade, being no less than from 6·85 to 12·30. This depends upon an abnormally high ratio in 1893 and an abnormally low one in 1897. Withdrawing these the range for the remaining eight years is reduced to from 7·70 to 10·60.

To check these results as far as possible, I give in Table X. a larger number of trees, including some additional species, treated in the same way, for the five years 1889-93. Here eleven species and twenty-six trees are dealt with. The range is from 7·45 to 9·80, and on the whole the fluctuations agree with those in the corresponding years in Table IX., 1893 in particular being decidedly the best year in both.

I have also found it possible to deal with 12 species and 23 trees for the eight years 1889-96, in Table XI. Here the range is from 10·20 to 13·00, and the agreement with the fluctuations in Table IX. is pretty close. The decided maximum is again in 1893, and the only marked difference is the comparatively small proportion of 1889 in Table IX., which, however, was almost entirely due to a single tree, *Abies Lowiana*, whose increase in that year fell 1·25 below that of 1888.

In Table IX. the remarkable fall from 10·60 in 1896 to 6·85 in 1897 was due to some cause which affected all the species with the exception of *Cedrus atlantica*, but this exception was more apparent than real, as, in fact, it had already fallen the previous year from 1·10 to ·50, the figure repeated in 1897.

## TABLE IX.

AVERAGE ANNUAL GIRTH-INCREASE AND RANGE IN TEN SPECIES OF CONIFERÆ FOR TEN YEARS—1888-1897.*

| | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | Total. | Av. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pinus excelsa (one) - - | ·90 | ·90 | 1·20 | 1·20 | 1·20 | 1·25 | 1·15 | ·90 | 1·20 | 1·05 | 10·95 | 1·09 |
| Abies grandis (one) - - | 1·15 | 1·65 | 1·25 | 1·60 | 2·10 | 2·50 | 2·25 | 1·85 | 1·95 | 1·65 | 17·95 | 1·79 |
| „ Lowiana (one) - | 1·55 | ·30 | 1·00 | 1·00 | 1·80 | 2·60 | 1·75 | 2·30 | 2·80 | ·95 | 16·05 | 1·60 |
| „ Douglasii (one) - | ·80 | ·40 | ·55 | ·65 | 1·00 | 1·25 | ·90 | 1·30 | 1·15 | ·85 | 8·85 | ·88 |
| „ Hookeriana (one) - | ·60 | ·70 | ·55 | ·50 | ·50 | ·55 | ·50 | ·55 | ·50 | ·45 | 5·40 | ·54 |
| Sequoia gigantea (one) - | 1·35 | ·90 | 1·25 | 1·25 | ·90 | ·95 | ·90 | ·65 | ·95 | ·45 | 9·55 | ·95 |
| Cedrus Deodara (four) - | ·95 | ·80 | ·90 | ·70 | ·55 | ·75 | ·75 | ·35 | ·70 | ·30 | 6·75 | ·67 |
| „ atlantica (one) - | 1·30 | 1·20 | 1·30 | 1·20 | 1·20 | 1·50 | 1·25 | 1·10 | ·50 | ·50 | 11·05 | 1·10 |
| Araucaria imbricata (two) | ·60 | ·45 | ·60 | ·60 | ·60 | ·60 | ·75 | ·45 | ·55 | ·50 | 5·70 | ·57 |
| Taxus baccata (four)- - | ·30 | ·40 | ·40 | ·35 | ·30 | ·35 | ·40 | ·25 | ·30 | ·15 | 3·20 | ·32 |
| | 9·50 | 7·70 | 9·00 | 9·05 | 10·15 | 12·30 | 10·60 | 9·70 | 10·60 | 6·85 | 95·45 | 9·51 |

* When more than one tree of a species is given, the average for the species is taken.

## TABLE X.

THE SAME FOR A LARGER NUMBER OF TREES AND SOME DIFFERENT SPECIES FOR 5 YEARS—1889-93.

| | 1889. | 1890. | 1891. | 1892. | 1893. | Total. | Av. |
|---|---|---|---|---|---|---|---|
| Pinus excelsa (two) - - | 1·10 | 1·25 | 1·10 | 1·30 | 1·05 | 5·80 | 1·16 |
| Abies Lowiana (two) - - | 1·05 | 1·45 | 1·30 | 1·75 | 2·20 | 7·75 | 1·55 |
| „ Douglasii (three) - - | ·90 | 1·00 | ·90 | 1·05 | 1·25 | 5·10 | 1·02 |
| Sequoia gigantea (four) - - | ·80 | 1·05 | 1·00 | ·80 | 1·05 | 4·70 | ·94 |
| Taxus baccata (six) - - | ·35 | ·40 | ·35 | ·30 | ·35 | 1·75 | ·35 |
| Pinus Pinaster (one) - - | ·80 | ·60 | ·60 | ·80 | ·95 | 3·75 | ·75 |
| „ Murrayana (one) - - | ·75 | ·75 | ·55 | ·70 | ·80 | 3·55 | ·71 |
| „ Laricio (one) - - | ·40 | ·40 | ·35 | ·25 | ·25 | 1·65 | ·33 |
| Cupressus Lawsoniana (two) | ·45 | ·65 | ·50 | ·65 | ·70 | 2·95 | ·59 |
| Thuja gigantea (two) - - | ·90 | ·85 | ·50 | ·70 | ·70 | 3·65 | ·73 |
| Retinospora obtusa (two) - | ·35 | ·35 | ·30 | ·40 | ·50 | 1·90 | ·38 |
| | 7·85 | 8·75 | 7·45 | 8·70 | 9·80 | 42·55 | 8·51 |

TABLE XI.

THE SAME FOR TWELVE SPECIES FOR EIGHT YEARS—1889-96.

| | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | Total | Av. |
|---|---|---|---|---|---|---|---|---|---|---|
| Pinus excelsa (two) | 1·10 | 1·25 | 1·10 | 1·30 | 1·05 | 1·05 | 1·25 | 1·20 | 9·30 | 1·16 |
| „ Laricio (one) | ·40 | ·40 | ·35 | ·25 | ·25 | ·40 | ·30 | ·40 | 2·75 | ·34 |
| „ Pinaster (one) | ·80 | ·40 | ·60 | ·80 | ·95 | ·55 | ·55 | ·55 | 5·20 | ·65 |
| „ Murrayana (one) | ·75 | ·75 | ·55 | ·70 | ·80 | ·60 | ·55 | ·60 | 5·30 | ·66 |
| Abies Douglasii (three) | ·90 | 1·00 | ·90 | 1·05 | 1·25 | 1·05 | 1·15 | 1·05 | 8·35 | 1·04 |
| „ grandis (one) | 1·65 | 1·25 | 1·60 | 2·10 | 2·50 | 2·25 | 1·85 | 1·95 | 15·15 | 1·90 |
| „ Lowiana (two) | 1·05 | 1·45 | 1·30 | 1·75 | 2·10 | 1·60 | 1·65 | 2·00 | 12·90 | 1·61 |
| „ Hookeriana (one) | ·70 | ·55 | ·50 | ·50 | ·55 | ·50 | ·55 | ·50 | 4·35 | ·54 |
| Sequoia gigantea (one) | ·90 | 1·25 | 1·25 | ·90 | ·95 | ·90 | ·65 | ·95 | 7·75 | ·97 |
| Cedrus Deodara (four) | ·80 | ·90 | ·70 | ·55 | ·75 | ·75 | ·35 | ·70 | 5·50 | ·69 |
| „ africana (one) | 1·20 | 1·30 | 1·20 | 1·20 | 1·50 | 1·25 | 1·10 | ·50 | 9·25 | 1·16 |
| Taxus baccata (four) | ·40 | ·40 | ·35 | ·30 | ·35 | ·40 | ·25 | ·30 | 2·75 | ·34 |
| | 10·65 | 10·90 | 10·40 | 11·40 | 13·00 | 11·30 | 10·20 | 10·70 | 88·55 | 11·06 |

## II. MONTHLY RESULTS.

Monthly observations on a considerable number of Coniferæ were not begun till 1882, and the results for the five years ending 1886 have already been given.[1] This set of comparatively old trees were then, perforce, given up, and a younger set were observed for a second five-years' period, 1887-91. As the results for these have also been published,[2] and as my monthly records of Coniferæ then ceased, I shall only give some of the general conclusions arrived at in these earlier investigations.

### A. AVERAGE MONTHLY PERCENTAGE IN THE COMPARATIVELY OLD CONIFERÆ, 1882-86.

| April. | May. | June. | July. | August. | Septr. |
|---|---|---|---|---|---|
| 8 | 22 | 26 | 24 | 18 | 2 |

[1] Trans. Bot. Soc., Edin., 1886-87.
[2] *Op cit.*, 1892.

The greatest percentages in the months were:—For April, 18 p.c. in *Pinus austriaca* and 16 p.c. in *Araucaria imbricata;* for May, 28 p.c. in *Abies Lowiana;* for June, 39 p.c. in *Sequoia gigantea;* for July, 30 p.c. in *Cupressus Lawsoniana;* for August, 30 p.c. in *Cedrus Deodara;* and for September, 8 p.c. in the same.

### 1. Proportional percentage of the first and second half-seasons of growth.

Excess in the first half was most marked in *Araucaria*, the proportions being 73 p.c. in the first and 27 p.c. in the second. The reverse was most marked in *Cedrus Deodara*, 34 p.c. in the first and 66 p.c. in the second.

### 2. Progressive increase and decrease in the growing season.

*Abies Lowiana* proved to be an exception to the normal seasonal progress, as its percentage, which was very large in May, 28 p.c., dropped in June to 18 p.c., rising again to 22 p.c. in July. *Cedrus Deodara* was remarkable for a steady rise to a maximum so late as in August.

### 3. Comparison with the Deciduous Group of the same period.

| | April. | May. | June. | July. | Aug. | Sept. |
|---|---|---|---|---|---|---|
| Coniferæ . . . . . | 8 | 22 | 26 | 24 | 18 | 2 |
| Deciduous . . . . . | 6 | 11 | 18 | 41 | 22 | 2 |

The Table shows that the increase was more equably distributed in the Coniferæ, and further investigation proved that this depended partly on the maxima of the species occurring in a greater variety of months, but partly also on a more equable distribution in the individual species.

B. AVERAGE MONTHLY PERCENTAGE IN THE YOUNGER CONIFERÆ, 1887-91, COMPARED WITH THE OLDER GROUP.

| | April. | May. | June. | July. | Aug. | Sept. |
|---|---|---|---|---|---|---|
| Younger Group - - - | 5·5 | 28 | 26·5 | 18·5 | 14·5 | 7 |
| Older Group - - - | 8 | 22 | 26 | 24 | 18 | 2 |

Compared with the older group there is a considerable difference in regard to the first and last months, the older group having a larger proportion in the first and a much smaller proportion in the last than the younger trees. But the difference is perhaps not greater than might be expected between two groups of different ages, to some extent of different species, and under observation at different periods, and difference almost disappears if we take the first and last two months together. In the older group the distribution is somewhat more equable and the maximum is attained later than in the younger trees.

### 1. Proportional percentage of the first and second half-seasons of growth.

The following Table shows that on comparing the two groups in this respect, the few species that occur in both have tolerably analogous results.

| YOUNGER GROUP. | | | OLDER GROUP. | | |
|---|---|---|---|---|---|
| | 1st Half. | 2nd Half. | | 1st Half. | 2nd Half. |
| Araucaria imbricata (2) | 75 | 25 | Araucaria imbricata (3)- | 73 | 27 |
| Cupressus Lawsoniana (2) | 73 | 27 | Séquoia gigantea (4) - | 66 | 34 |
| Pinus austriaca (1) - | 71·5 | 28 | Pinus austriaca (1) - | 64 | 36 |
| Retinospora obtusa (1) - | 70·5 | 29 | Cupressus Lawsoniana (1) | 63 | 37 |
| Thuja gigantea (1) - | 67·5 | 32 | Abies Lowiana (1) - | 56 | 44 |
| Pinus Pinaster (1) - | 62·5 | 37 | Cedrus africana (1) - | 48 | 52 |
| ,, excelsa (3) - - | 55·5 | 44 | Taxus baccata (4) - - | 45 | 55 |
| ,, Murrayana (1) - | 55·5 | 44 | Cedrus Deodara (4) - | 34 | 66 |
| Abies Douglasii (3) - | 54 | 46 | | | |
| ,, Hookeriana (1) - | 51 | 49 | | | |
| ,, Lowiana (2) - - | 47 | 53 | | | |
| ,, grandis (1) - - | 33 | 67 | | | |

That the species do follow a law in throwing the mass of their growth, some into the early others into the late part of the growing season, seems fairly well indicated by a list showing the percentage of growth in the first and last half-seasons in thirty-four Coniferæ, thirteen of the old and twenty-one of the new set, in my Paper in the Transactions of the Botanical Society of Edinburgh, 1892, p. 325. The list is drawn up in the order of greatest proportion in the first half-season, one example of *Araucaria imbricata* being at the head with 79 p.c. and one of the deodars at the foot with 24 p.c.

On analysing the list of 34 trees, it appears that the four araucarias are within eleven places of the top; the three deodars within five places of the bottom, and their near relative *Cedrus africana* separated from them only by a single place: the three each of *Abies Douglasii*, *Cupressus Lawsoniana*, *Sequoia gigantea*, *Abies Lowiana*, and *Pinus excelsa* within fourteen, thirteen, twelve, nine, and nine places respectively of each other. Taking a wider view, the seven trees of four species of *Abies* are all in the lower half of the list, and six of the seven trees of four species of *Pinus* are within thirteen places, in the middle of the list.

## 2. Distribution of the girth-increase over the growing season in the younger Coniferæ.

There was a considerable variety in the conduct of the species in this respect. Some showed a marked activity for only three months, others for four or five. As examples of a wide distribution over the growing season in undoubtedly healthy vigorous growers the following may be taken, the averages being for a period of five years:—

PERCENTAGES OF MONTHLY INCREASE.

| No. | | April. | May. | June. | July. | Aug. | Sept. |
|---|---|---|---|---|---|---|---|
| 2 | Pinus excelsa - - | 8 | 21·5 | 26 | 21 | 14 | 9·5 |
| 11 | Do. do. - - | 8·5 | 17 | 27 | 17 | 17 | 13·5 |
| 91 | Abies grandis . - | 6 | 19·5 | 7·5 | 20 | 27 | 20 |

### 3. Progressive increase and decrease in the growing season.

*Abies Lowiana* again showed a deviation from the normal monthly rise to a maximum, as the percentage was slightly less in June than in May; this deviation also revealed itself in *Abies Douglasii*, *Pinus excelsa*, and *Thuja gigantea*, but above all in *Abies grandis*, the healthiest and quickest grower of all my Coniferæ, where, therefore, disease or weakness cannot be suspected as a cause, in which the percentage was 19·5 in May and fell to no more than 7·5 in June, rising again in July to 20·0. Subsequent weekly measurements of this tree showed that there was a complete cessation of increase for at least a fortnight in June.

### 4. Comparison with the Deciduous Group of the same period.

| | April. | May. | June. | July. | Aug. | Sept. |
|---|---|---|---|---|---|---|
| Coniferæ - - - - | 5·5 | 28 | 26·5 | 18·5 | 14·5 | 7 |
| Deciduous - - - - | 1·5 | 12 | 31 | 30 | 20·5 | 5 |

The increase is somewhat more evenly distributed in the Coniferæ. It is greater than in the Deciduous Trees both in the first and last months, and if we take the first and last bi-monthly periods, it is much greater in the first and a little less in the last, whereas in the middle bi-monthly period the Deciduous class has considerably the best of it. The results agree fairly well with the comparison already made in the older groups.

Number V.

# NOTES

FROM THE

# ROYAL BOTANIC GARDEN,

# EDINBURGH.

## DECEMBER 1901.

CONTENTS.



GLASGOW:
PRINTED FOR HIS MAJESTY'S STATIONERY OFFICE
By JAMES HEDDERWICK & SONS,
AT "THE CITIZEN" PRESS, ST. VINCENT PLACE.

SOLD AT THE GARDEN,
And to be purchased, either directly or through any Bookseller, from
OLIVER & BOYD, Edinburgh.

[PRICE NINEPENCE.]

# The Diameter-Increment of Trees.[1]

BY

A. W. BORTHWICK, B.Sc.

There are two methods, apart from the use of callipers, by which the diameter-increment or rate of growth in thickness of trees can be ascertained. One of these—the tape-method—has already been described by Dr. Christison; the other is by use of a very simple instrument invented by Pressler, and known as Pressler's increment-borer. By means of this instrument cylinders of wood about a quarter-inch in diameter and from two to six inches long—according to species—can be extracted, and upon these the breadth of the year-rings may be measured. In order to allow for any eccentricity or irregularity of growth it is safer to take the mean of four cylinders, one from each end of two diameters at right angles.

The great difference between these two methods is that the tape-method requires a very considerable period of time in order to get reliable results, as we cannot draw an average from one or two season's growths. In very few cases have careful measurements extending over a long period of time been carried out, but in the whole history of British arboriculture there is no place where more extensive and careful girth-measurements have been made than in the Royal Botanic Garden, Edinburgh.[1]

By the kind permission of the Regius Keeper I have had the rare opportunity of testing whether the increment-borer would yield the same, or approximately the same, results as were obtained by Dr. Christison by means of the tape. The trees I examined were those measured by Dr. Christison, and the

[1] See Notes from the Royal Botanic Garden, Edinburgh, Number III. (1900), p. 41.

numbers attached to the trees are those of his lists. In many cases I was able to extract cylinders fully five inches long, and in no case less than two inches. The length of the cylinder is, however, not necessarily an indication of the number of year-rings in it. A cylinder five inches long from a broad-ringed or fast-growing tree may contain no more or even fewer year-rings than a cylinder four inches long from a narrow-ringed or slow-growing tree. The greatest number of year-rings extracted was forty from a horse-chestnut, while fifteen to twenty-five was an easily obtained number from other species. (See Table I.)

The breadth of the year-rings sometimes varies greatly on different sides of the same tree, especially in isolated trees which have not been grown in the company of others. This was well shown on many of the cylinders, so that cylinders of the same length from different sides of the tree do not necessarily have the same number of year-rings, and conversely cylinders with the same number of year-rings are not necessarily of equal lengths. This can be seen from the accompanying Table III.

Having got the four borings I counted off the number of year-rings in each. It was generally found that one of the cylinders showed a smaller number than any of the others. I therefore marked off this number ( say $n$) on each of the other cylinders, disregarding any that were left over, as they did not come into consideration in making out an average. Having done this, I next found the aggregate length of the cylinders for this number of year-rings, and by dividing this by two and subtracting the result from the present diameter (bark included) I obtained the diameter which the tree had as many years ago as there were marked off rings in the cylinders. I next subtracted in succession twice the mean breadth of each annual ring from the diameter of the corresponding year, which gave the diameter of the preceding year. This operation gave the intermediate diameters and again the diameter $n$ years ago. The first operation was an excellent means of checking the second.

It was then an easy matter to get the circumference for each year from the diameters. By subtracting the circumference for a certain year from that of the year following I got the circumference increment.

On comparing the results obtained by both methods—tape and

borer—it is extremely interesting to find how closely they coincide. The actual figures are not the same, because the borings were not taken at the same level as the tape-measurements. I purposely took them slightly higher or lower as seemed expedient in order not to interfere with the marked circumference measured by Dr. Christison.

Although the actual figures for each separate year do not exactly coincide, still the mean or average increment for a period of five or ten years does correspond very closely. In order to show the parallelism between both methods I have arranged the final results in adjacent columns in the appended Table 11.

It has been suggested that the increment-borer might damage the trees, but if care is taken to properly fill up the holes no danger can possibly exist. I may also point out that a very short time is required for the tree to naturally occlude such a trifling wound as the instrument makes. In almost every case the trees which I bored in the spring of last year were occluded by the autumn of this year and scarcely any trace of a scar remains.

The increment-borer can also be used in pathological work. For example, in making artificial infections, in order to study the course of development and effect on the tree of any wood-destroying fungus, there is no better method than to introduce a cylinder bored from a diseased tree into a healthy one. It is then an easy matter to extract cylinders from such an artificially infected tree at different times and from different parts, and thus get exact information regarding the rate at which the disease spreads and the various pathological appearances presented by the wood as the disease runs its course.

In determining the age of trees, if the diameter is not more than one foot the number of year-rings on an extracted cylinder will give this at once. If it is not possible to bore right into the centre we can still obtain the number of year rings on a certain length of the radius and from this compute the probable amount on the whole, always taking care to allow for the greater year-ring breadth near the centre of the stem. In many cases the pith is eccentric; if, therefore, we bore four cylinders in the radial direction one of them is generally found to reach the pith even though the diameter of the stem be more than one foot.

The relation between the wood-mass of a tree and the time taken to produce it is a subject of considerable scientific and practical importance. No matter whether the trees are grown for ornamental or economic purposes, a knowledge of the relation between time-increment and volume-increment cannot fail to be of great service. The proprietor of parks and ornamental policy-grounds is always interested to know how his trees are doing, whether they are still increasing by growth or are already mature. On the other hand in economic forestry it is essential to know the amount of timber which is or can be produced in a given time under certain climatic conditions and sylvicultural treatment, otherwise financial calculations cannot be made with anything like the degree of accuracy which the case demands. The manifold external conditions influencing the growth of trees and plants in general make it well-nigh impossible to lay down any definite rules which are generally applicable for all species. A tree which is a fast grower in one locality may behave very differently in another, hence it is necessary for accurate results to collect statistics for each locality.

At present the German yield-tables are used in this country, and for general purposes are found to be approximately accurate, but the mere fact that in Germany local yield-tables are found to be necessary shows that the general yield-tables are not indiscriminately applicable. Our climate being an insular one, milder and moister, is bound to have a different effect on tree-growth from the continental climate of Europe.

If statistics were collected, especially for the Highlands, to which the German yield-tables are probably least applicable, they would be of great service to the forester, especially in making out working plans to guide the future management of the forests.

[TABLE.

## I.

## DIAMETER-INCREMENT AND NUMBER OF YEAR-RINGS BORED.

| | Increment in Inches. | No. of Rings. |
|---|---|---|
| Æsculus | 9·44 | 40 |
| Carpinus Betulus | 2·01 | 20 |
| Castanea vesca | 7·58 | 28 |
| Cedrus | 8·82 | 23 |
| Fagus sylvatica | 3·91 | 14 |
| " " | 3·71 | 14 |
| Fraxinus excelsior | 3·39 | 12 |
| Liriodendron | 3·17 | 21 |
| Quercus Cerris | 2·05 | 12 |
| " " | 4·54 | 12 |
| Taxus | 3·62 | 28 |
| Tilia | 1·74 | 20 |
| Ulmus | 7·06 | 15 |

## II.

## COMPARISON OF DR. CHRISTISON'S RESULTS OBTAINED BY MEANS OF TAPE WITH THOSE OBTAINED BY MEANS OF PRESSLER'S BORER.[1]

| ÆSCULUS. Tape. | ÆSCULUS. Borer. | CARPINUS. Tape. | CARPINUS. Borer. |
|---|---|---|---|
| ·35 | ·37 | ·25 | ·31 |
| ·5 | ·38 | ·40 | ·31 |
| ·10 | ·21 | ·45 | ·37 |
| ·00 | ·12 | ·30 | ·28 |
| ·25 | ·09 | ·45 | ·31 |
| ·10 | ·18 | ·55 | ·37 |
| ·25 | ·09 | ·35 | ·40 |
| ·25 | ·18 | ·30 | ·21 |
| ·30 | ·16 | ·50 | ·31 |
| ·00 | ·12 | ·25 | ·31 |
| 1·65 | 1·90 | 3·80 | 3·18 |
| | 1·90 | | 3·80 |
| | 1·65 | | 3·18 |
| Circum. Diff. = | ·25 | Circum. Diff. = | ·62 |
| Diam. Diff.[2] = | ·08 | Diam. Diff. = | ·20 |
| Mean Annual Diff.= | ·008 | Mean Annual Diff.= | ·02 |

[1] Measurements in both cases are in inches.

[2] The Circumference-Difference has been divided in each case by 3. This gives the Diameter-Difference roughly, but near enough for the present purpose.

CASTANEA VESCA.

| Tape. | | Borer. |
|---|---|---|
| ·60 | - - - | ·78 |
| ·75 | - - - | ·81 |
| 1·00 | - - - | ·65 |
| ·60 | - - - | ·78 |
| ·90 | - - - | ·81 |
| ·90 | - - - | ·59 |
| ·40 | - - - | ·65 |
| ·80 | - - - | ·53 |
| ·45 | - - - | ·50 |
| ·55 | - - - | ·69 |
| 6·95 | | 6·79 |
| | | 6·95 |
| | | 6·79 |
| Circum. Diff. = | - | ·17 |
| Diam. Diff. = - | - | ·06 |
| Mean Annual Diff.= | | ·006 |

CEDRUS ATLANTICA.

| Tape. | | Borer. |
|---|---|---|
| 1·30 | - - - | 1·09 |
| 1·20 | - - - | 1·16 |
| 1·30 | - - - | 1·13 |
| 1·20 | - - - | 1·03 |
| 1·20 | - - - | 1·19 |
| 1·50 | - - - | 1·53 |
| 1·25 | - - - | 1·44 |
| 1·10 | - - - | 1·13 |
| ·50 | - - - | ·34 |
| ·50 | - - - | ·53 |
| 11·05 | | 10·57 |
| | | 11·05 |
| | | 10·57 |
| Circum. Diff. = | - | ·48 |
| Diam. Diff. = | - | ·16 |
| Mean Annual Diff.= | | ·016 |

FAGUS SYLVATICA.

| Tape. | | Borer. |
|---|---|---|
| ·75 | - - - | ·87 |
| ·80 | - - - | ·75 |
| ·95 | - - - | ·94 |
| ·90 | - - - | ·91 |
| 1·20 | - - - | ·87 |
| 1·10 | - - - | ·87 |
| ·85 | - - - | ·87 |
| ·60 | - - - | ·69 |
| ·90 | - - - | ·81 |
| ·80 | - - - | ·78 |
| 8·85 | | 8·36 |
| | | 8·85 |
| | | 8·36 |
| Circum. Diff. = | - | ·49 |
| Diam. Diff. = - | - | ·16 |
| Annual Mean Diff.= | | ·016 |

FAGUS SYLVATICA.

| Tape. | | Borer. |
|---|---|---|
| ·80 | - - - | ·97 |
| ·95 | - - - | ·97 |
| ·95 | - - - | ·97 |
| ·90 | - - - | ·87 |
| ·90 | - - - | ·94 |
| ·90 | - - - | ·87 |
| ·90 | - - - | ·72 |
| ·90 | - - - | ·72 |
| 1·10 | - - - | ·94 |
| ·90 | - - - | ·65 |
| 9·20 | | 8·62 |
| | | 9·20 |
| | | 8·62 |
| Circum. Diff. = | - | ·58 |
| Diam. Diff. = | - | ·19 |
| Annual Mean Diff.= | | ·019 |

### FRAXINUS EXCELSIOR.

| Tape. | Borer. |
|---|---|
| ... | ... |
| ... | ... |
| ... | ... |
| ... | ... |
| 1·30 | 1·09 |
| 1·10 | 1·13 |
| 1·20 | 1·25 |
| 1·25 | 1·19 |
| ... | ... |
| ... | ... |
| 4·85 | 4·66 |
| | 4·85 |
| | 4·66 |
| Circum. Diff. = | ·19 |
| Diam. Diff. = | ·06 |
| Mean Annual Diff. = | ·006 |

### LIRIODENDRON.

| Tape. | Borer. |
|---|---|
| ·35 | ·40 |
| ·40 | ·31 |
| ·80 | ·59 |
| ·50 | ·53 |
| ·65 | ·33 |
| ·40 | ·50 |
| ·75 | ·43 |
| ·35 | ·43 |
| ·40 | ·37 |
| ·25 | ·21 |
| 4·85 | 4·10 |
| | 4·85 |
| | 4·10 |
| Circum. Diff. = | ·75 |
| Diam. Diff. = | ·25 |
| Mean Annual Diff. = | ·025 |

### QUERCUS CERRIS.

| Tape. | Borer. |
|---|---|
| ·70 | ·47 |
| ·45 | ·37 |
| ·65 | ·56 |
| ·50 | ·47 |
| ·70 | ·47 |
| ·85 | ·62 |
| ·70 | ·62 |
| ·55 | ·47 |
| ·80 | ·65 |
| ·60 | ·65 |
| 6·50 | 5·35 |
| | 6·50 |
| | 5·35 |
| Circum. Diff. = | 1·15 |
| Diam. Diff. = | ·35 |
| Mean Annual Diff. = | ·035 |

### QUERCUS CONFERTA.

| Tape. | Borer. |
|---|---|
| 1·30 | 1·35 |
| 1·75 | 1·25 |
| 2·05 | 1·94 |
| 1·50 | 1·57 |
| 1·75 | 1·66 |
| 2·30 | 1·79 |
| ... | ... |
| ... | ... |
| ... | ... |
| ... | ... |
| 10·65 | 9·56 |
| | 10·65 |
| | 9·56 |
| Circum. Diff. = | 1·09 |
| Diam. Diff. = | ·36 |
| Mean Annual Diff. = | ·036 |

TAXUS.

| Tape. | Borer. |
|---|---|
| ·40 | ·37 |
| ·60 | ·50 |
| ·55 | ·47 |
| ·55 | ·40 |
| ·45 | ·31 |
| ·45 | ·40 |
| ·45 | ·40 |
| ·40 | ·31 |
| ·55 | ·37 |
| ·20 | ·34 |
| 4·55 | 3·87 |
| | 4·55 |
| | 3·87 |
| Circum. Diff. = | ·68 |
| Diam. Diff. = | ·22 |
| Mean Annual Diff. = | ·022 |

TILIA.

| Tape. | Borer. |
|---|---|
| ·00 | ·18 |
| ·50 | ·09 |
| ·40 | ·21 |
| ·25 | ·28 |
| ·20 | ·31 |
| ·40 | ·28 |
| ·35 | ·34 |
| ·00 | ·25 |
| ·30 | ·28 |
| ·35 | ·31 |
| 2·75 | 2·53 |
| | 2·75 |
| | 2·53 |
| Circum. Diff. = | ·22 |
| Diam. Diff. = | 07 |
| Mean Annual Diff. = | ·007 |

ULMUS.

| Tape. | Borer. |
|---|---|
| 1·75 | 1·66 |
| 1·80 | 2·16 |
| 1·75 | 1·72 |
| 1·50 | 1·82 |
| 1·30 | 1·34 |
| 1·70 | 1·57 |
| 1·60 | 1·19 |
| 2·05 | 0·94 |
| 1·75 | 1·57 |
| 1·35 | 1·44 |
| 16·55 | 15·41 |
| | 16·55 |
| | 15·41 |
| Circum. Diff. = | 1·14 |
| Diam. Diff. = | ·38 |
| Mean Annual Diff. = | ·038 |

## III.

## DETAILED RESULTS OBTAINED BY MEANS OF PRESSLER'S BORER.

### ÆSCULUS HIPPOCASTANUM.

**Diam. Inct. for 40 years = 9·44. Diam. in 1899 = 17·16. Diam. in 1859 = 7·72.**

| Year. | N. | S. | E. | W. | Sum. | Average. | | Diameter. | Circumference. | Circumference Increment. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Vulg. | Decimal. | | | |
| 1860 | $\frac{14}{64}$ | $\frac{12}{64}$ | $\frac{8}{64}$ | $\frac{9}{64}$ | $\frac{43}{64}$ | $\frac{43}{128}$ | ·33 | 8·05 | 25·289880 | 1·036728 |
| 1861 | $\frac{14}{64}$ | $\frac{12}{64}$ | $\frac{10}{64}$ | $\frac{11}{64}$ | $\frac{47}{64}$ | $\frac{47}{128}$ | ·36 | 8·41 | 26·420856 | 1·130976 |
| 1862 | $\frac{14}{64}$ | $\frac{15}{64}$ | $\frac{10}{64}$ | $\frac{12}{64}$ | $\frac{51}{64}$ | $\frac{51}{128}$ | ·39 | 8·80 | 27·646080 | 1·225224 |
| 1863 | $\frac{13}{64}$ | $\frac{14}{64}$ | $\frac{10}{64}$ | $\frac{11}{64}$ | $\frac{48}{64}$ | $\frac{3}{8}$ | ·37 | 9·17 | 28·808472 | 1·162392 |
| 1864 | $\frac{10}{64}$ | $\frac{12}{64}$ | $\frac{15}{64}$ | $\frac{15}{64}$ | $\frac{52}{64}$ | $\frac{21}{64}$ | ·32 | 9·49 | 29·813784 | 1·005312 |
| 1865 | $\frac{15}{64}$ | $\frac{12}{64}$ | $\frac{14}{64}$ | $\frac{14}{64}$ | $\frac{55}{64}$ | $\frac{55}{128}$ | ·42 | 9·91 | 31·133256 | 1·319472 |
| 1866 | $\frac{11}{64}$ | $\frac{14}{64}$ | $\frac{11}{64}$ | $\frac{12}{64}$ | $\frac{48}{64}$ | $\frac{3}{8}$ | ·37 | 10·28 | 32·295648 | 1·162392 |
| 1867 | $\frac{13}{64}$ | $\frac{12}{64}$ | $\frac{11}{64}$ | $\frac{12}{64}$ | $\frac{48}{64}$ | $\frac{3}{8}$ | ·37 | 10·65 | 33·458040 | 1·162392 |
| 1868 | $\frac{13}{64}$ | $\frac{11}{64}$ | $\frac{13}{64}$ | $\frac{12}{64}$ | $\frac{49}{64}$ | $\frac{49}{128}$ | ·38 | 11·03 | 34·651848 | 1·193808 |
| 1869 | $\frac{12}{64}$ | $\frac{11}{64}$ | $\frac{7}{64}$ | $\frac{11}{64}$ | $\frac{41}{64}$ | $\frac{41}{128}$ | ·32 | 11·35 | 35·657160 | 1·005312 |
| 1870 | $\frac{12}{64}$ | $\frac{14}{64}$ | $\frac{5}{64}$ | $\frac{12}{64}$ | $\frac{43}{64}$ | $\frac{43}{128}$ | ·33 | 11·68 | 36·693888 | 1·036728 |
| 1871 | $\frac{15}{64}$ | $\frac{12}{64}$ | $\frac{13}{64}$ | $\frac{11}{64}$ | $\frac{51}{64}$ | $\frac{51}{128}$ | ·39 | 12·07 | 37·919112 | 1·225224 |
| 1872 | $\frac{15}{64}$ | $\frac{9}{64}$ | $\frac{10}{64}$ | $\frac{11}{64}$ | $\frac{45}{64}$ | $\frac{45}{128}$ | ·35 | 12·42 | 39·018672 | 1·099560 |
| 1873 | $\frac{15}{64}$ | $\frac{11}{64}$ | $\frac{11}{64}$ | $\frac{11}{64}$ | $\frac{48}{64}$ | $\frac{3}{8}$ | ·37 | 12·79 | 40·181064 | 1·162392 |
| 1874 | $\frac{14}{64}$ | $\frac{13}{64}$ | $\frac{11}{64}$ | $\frac{9}{64}$ | $\frac{47}{64}$ | $\frac{47}{128}$ | ·36 | 13·15 | 41·312040 | 1·130976 |
| 1875 | $\frac{11}{64}$ | $\frac{12}{64}$ | $\frac{8}{64}$ | $\frac{12}{64}$ | $\frac{43}{64}$ | $\frac{43}{128}$ | ·33 | 13·48 | 42·348768 | 1·036728 |
| 1876 | $\frac{11}{64}$ | $\frac{11}{64}$ | $\frac{11}{64}$ | $\frac{11}{64}$ | $\frac{44}{64}$ | $\frac{11}{32}$ | ·34 | 13·82 | 43·416912 | 1·068144 |
| 1877 | $\frac{13}{64}$ | $\frac{9}{64}$ | $\frac{11}{64}$ | $\frac{10}{64}$ | $\frac{43}{64}$ | $\frac{43}{128}$ | ·33 | 14·15 | 44·453640 | 1·036728 |
| 1878 | $\frac{14}{64}$ | $\frac{8}{64}$ | $\frac{11}{64}$ | $\frac{11}{64}$ | $\frac{44}{64}$ | $\frac{11}{32}$ | ·34 | 14·49 | 45·521784 | 1·068144 |
| 1879 | $\frac{14}{64}$ | $\frac{10}{64}$ | $\frac{8}{64}$ | $\frac{12}{64}$ | $\frac{44}{64}$ | $\frac{11}{32}$ | ·34 | 14·83 | 46·589928 | 1·068144 |
| 1880 | $\frac{7}{64}$ | $\frac{8}{64}$ | $\frac{8}{64}$ | $\frac{13}{64}$ | $\frac{36}{64}$ | $\frac{9}{32}$ | ·28 | 15·11 | 47·469576 | ·879468 |
| 1881 | $\frac{5}{64}$ | $\frac{5}{64}$ | $\frac{8}{64}$ | $\frac{13}{64}$ | $\frac{31}{64}$ | $\frac{31}{128}$ | ·24 | 15·35 | 48·223560 | ·753984 |
| 1882 | $\frac{5}{64}$ | $\frac{7}{64}$ | $\frac{13}{64}$ | $\frac{12}{64}$ | $\frac{37}{64}$ | $\frac{37}{128}$ | ·28 | 15·63 | 49·103208 | ·879648 |
| 1883 | $\frac{6}{64}$ | $\frac{6}{64}$ | $\frac{12}{64}$ | $\frac{8}{64}$ | $\frac{32}{64}$ | $\frac{1}{4}$ | ·25 | 15·88 | 49·888608 | ·785400 |
| 1884 | $\frac{5}{64}$ | $\frac{7}{64}$ | $\frac{8}{64}$ | $\frac{6}{64}$ | $\frac{26}{64}$ | $\frac{13}{64}$ | ·20 | 16·08 | 50·516928 | ·628320 |
| 1885 | $\frac{7}{64}$ | $\frac{8}{64}$ | $\frac{4}{64}$ | $\frac{8}{64}$ | $\frac{27}{64}$ | $\frac{27}{128}$ | ·21 | 16·29 | 51·176664 | ·659736 |
| 1886 | $\frac{3}{64}$ | $\frac{2}{64}$ | $\frac{3}{64}$ | $\frac{7}{64}$ | $\frac{15}{64}$ | $\frac{15}{128}$ | ·11 | 16·40 | 51·522240 | ·345576 |
| 1887 | $\frac{3}{64}$ | $\frac{3}{64}$ | $\frac{3}{64}$ | $\frac{6}{64}$ | $\frac{15}{64}$ | $\frac{15}{128}$ | ·11 | 16·51 | 51·867816 | ·345576 |
| 1888 | $\frac{3}{64}$ | $\frac{5}{64}$ | $\frac{3}{64}$ | $\frac{5}{64}$ | $\frac{16}{64}$ | $\frac{1}{8}$ | ·12 | 16·63 | 52·244808 | ·376992 |
| 1889 | $\frac{3}{64}$ | $\frac{3}{64}$ | $\frac{4}{64}$ | $\frac{2}{64}$ | $\frac{12}{64}$ | $\frac{3}{32}$ | ·09 | 16·72 | 52·527552 | ·382744 |
| 1890 | $\frac{3}{64}$ | $\frac{3}{64}$ | $\frac{2}{64}$ | $\frac{1}{64}$ | $\frac{9}{64}$ | $\frac{9}{128}$ | ·07 | 16·79 | 52·747464 | ·219912 |
| .. | .. | .. | .. | .. | .. | .. | 9·44 | .. | .. | .. |

## ÆSCULUS HIPPOCASTANUM—*Continued.*

| Year. | N. | S. | E. | W. | Sum. | Average. | | Diameter | Circumference. | Circumference Increment. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Vulg. | Decimal. | | | |
| 1891 | $\frac{3}{64}$ | $\frac{1}{64}$ | $\frac{1}{64}$ | $\frac{1}{64}$ | $\frac{6}{64}$ | $\frac{3}{64}$ | ·04 | 16·83 | 52·873128 | ·125664 |
| 1892 | $\frac{1}{64}$ | $\frac{1}{64}$ | $\frac{1}{64}$ | $\frac{1}{64}$ | $\frac{4}{64}$ | $\frac{1}{32}$ | ·03 | 16·86 | 52·967376 | ·094248 |
| 1893 | $\frac{1}{64}$ | $\frac{3}{64}$ | $\frac{2}{64}$ | $\frac{2}{64}$ | $\frac{8}{64}$ | $\frac{1}{16}$ | ·06 | 16·92 | 53·155872 | ·188496 |
| 1894 | $\frac{1}{64}$ | $\frac{1}{64}$ | $\frac{2}{64}$ | $\frac{1}{64}$ | $\frac{5}{64}$ | $\frac{5}{128}$ | ·03 | 16·95 | 53·250120 | ·094248 |
| 1895 | $\frac{3}{64}$ | $\frac{3}{64}$ | $\frac{1}{64}$ | $\frac{1}{64}$ | $\frac{8}{64}$ | $\frac{1}{16}$ | ·06 | 17·01 | 53·438616 | ·188496 |
| 1896 | $\frac{2}{64}$ | $\frac{2}{64}$ | $\frac{1}{64}$ | $\frac{1}{64}$ | $\frac{7}{64}$ | $\frac{7}{128}$ | ·05 | 17·06 | 53·595696 | ·157080 |
| 1897 | $\frac{3}{64}$ | $\frac{1}{64}$ | $\frac{1}{64}$ | $\frac{1}{64}$ | $\frac{6}{64}$ | $\frac{3}{64}$ | ·04 | 17·10 | 53·721360 | ·125664 |
| 1898 | $\frac{2}{64}$ | $\frac{1}{64}$ | $\frac{1}{64}$ | $\frac{1}{64}$ | $\frac{5}{64}$ | $\frac{5}{128}$ | ·03 | 17·13 | 53·815608 | ·094248 |
| 1899 | $\frac{1}{64}$ | $\frac{1}{64}$ | $\frac{1}{64}$ | $\frac{1}{64}$ | $\frac{4}{64}$ | $\frac{1}{32}$ | ·03 | 17·16 | 54·909856 | ·094248 |
| .. | .. | .. | .. | .. | .. | .. | 9·44 | .. | .. | .. |

## CARPINUS BETULUS, NO. 33.

Diam. Inct. for 20 years = 2·01. Diam. in 1899 = 17. Diam. in 1879 = 14·99.

| Year. | N. | S. | E. | W. | Sum. | Average. | | Diameter. | Circumference. | Circumference Increment. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Vulg. | Decimal. | | | |
| 1880 | $\frac{2}{64}$ | $\frac{3}{64}$ | $\frac{3}{64}$ | $\frac{3}{64}$ | $\frac{11}{64}$ | $\frac{3}{32}$ | ·09 | 15·08 | 47·375328 | ·282744 |
| 1881 | $\frac{2}{64}$ | $\frac{3}{64}$ | $\frac{3}{64}$ | $\frac{4}{64}$ | $\frac{12}{64}$ | $\frac{3}{32}$ | ·09 | 15·17 | 47·658072 | ·282744 |
| 1882 | $\frac{3}{64}$ | $\frac{4}{64}$ | $\frac{3}{64}$ | $\frac{5}{64}$ | $\frac{15}{64}$ | $\frac{15}{128}$ | ·11 | 15·28 | 48·003648 | |
| 1883 | $\frac{3}{64}$ | $\frac{4}{64}$ | $\frac{4}{64}$ | $\frac{6}{64}$ | $\frac{17}{64}$ | $\frac{17}{128}$ | ·13 | 15·41 | 48·412056 | ·408408 |
| 1884 | $\frac{3}{64}$ | $\frac{4}{64}$ | $\frac{4}{64}$ | $\frac{6}{64}$ | $\frac{17}{64}$ | $\frac{17}{128}$ | ·13 | 15·54 | 48·820464 | ·408408 |
| 1885 | $\frac{4}{64}$ | $\frac{4}{64}$ | $\frac{4}{64}$ | $\frac{4}{64}$ | $\frac{16}{64}$ | $\frac{1}{8}$ | ·12 | 15·66 | 49·197456 | ·376992 |
| 1886 | $\frac{2}{64}$ | $\frac{3}{64}$ | $\frac{2}{64}$ | $\frac{4}{64}$ | $\frac{11}{64}$ | $\frac{11}{128}$ | ·08 | 15·74 | 49·448784 | ·251328 |
| 1887 | $\frac{2}{64}$ | $\frac{4}{64}$ | $\frac{5}{64}$ | $\frac{5}{64}$ | $\frac{16}{64}$ | $\frac{1}{8}$ | ·12 | 15·86 | 49·825776 | ·376992 |
| 1888 | $\frac{4}{64}$ | $\frac{3}{64}$ | $\frac{4}{64}$ | $\frac{3}{64}$ | $\frac{14}{64}$ | $\frac{7}{64}$ | ·10 | 15·96 | 50·139936 | ·314160 |
| 1889 | $\frac{2}{64}$ | $\frac{2}{64}$ | $\frac{4}{64}$ | $\frac{5}{64}$ | $\frac{13}{64}$ | $\frac{13}{128}$ | ·10 | 16·06 | 50·454096 | ·314160 |
| 1890 | $\frac{3}{64}$ | $\frac{3}{64}$ | $\frac{4}{64}$ | $\frac{6}{64}$ | $\frac{16}{64}$ | $\frac{1}{8}$ | ·12 | 16·18 | 50·831088 | ·376992 |
| 1891 | $\frac{2}{64}$ | $\frac{4}{64}$ | $\frac{3}{64}$ | $\frac{3}{64}$ | $\frac{12}{64}$ | $\frac{3}{32}$ | ·09 | 16·27 | 51·113832 | ·282744 |
| 1892 | $\frac{1}{64}$ | $\frac{3}{64}$ | $\frac{4}{64}$ | $\frac{6}{64}$ | $\frac{14}{64}$ | $\frac{7}{64}$ | ·10 | 16·37 | 51·427992 | ·314160 |
| 1893 | $\frac{3}{64}$ | $\frac{4}{64}$ | $\frac{4}{64}$ | $\frac{5}{64}$ | $\frac{16}{64}$ | $\frac{1}{8}$ | ·12 | 16·49 | 51·804984 | ·376992 |
| 1894 | $\frac{3}{64}$ | $\frac{4}{64}$ | $\frac{3}{64}$ | $\frac{7}{64}$ | $\frac{17}{64}$ | $\frac{17}{128}$ | ·13 | 16·62 | 52·213392 | ·408408 |
| 1895 | $\frac{1}{64}$ | $\frac{2}{64}$ | $\frac{2}{64}$ | $\frac{4}{64}$ | $\frac{9}{64}$ | $\frac{9}{128}$ | ·07 | 16·69 | 52·433304 | ·219912 |
| 1896 | $\frac{3}{64}$ | $\frac{3}{64}$ | $\frac{3}{64}$ | $\frac{4}{64}$ | $\frac{13}{64}$ | $\frac{13}{128}$ | ·10 | 16·79 | 52·747464 | ·314160 |
| 1897 | $\frac{3}{64}$ | $\frac{3}{64}$ | $\frac{2}{64}$ | $\frac{6}{64}$ | $\frac{14}{64}$ | $\frac{7}{64}$ | ·10 | 16·89 | 53·061624 | ·314160 |
| 1898 | $\frac{2}{64}$ | $\frac{2}{64}$ | $\frac{1}{64}$ | $\frac{3}{64}$ | $\frac{8}{64}$ | $\frac{1}{16}$ | ·06 | 16·95 | 53·250120 | ·188496 |
| 1899 | $\frac{2}{64}$ | $\frac{2}{64}$ | $\frac{1}{64}$ | $\frac{2}{64}$ | $\frac{7}{64}$ | $\frac{7}{128}$ | ·05 | 17· | 53·407200 | ·157080 |
| .. | .. | .. | .. | .. | .. | .. | 2·01 | .. | .. | .. |

## CEDRUS ATLANTICA, No. 30.

**Diam. Inct. for 23 years = 8·82.** **Diam. in 1899 = 18·43.** **Diam. in 1876 = 9·61.**

| Year. | N. | S. | E. | W. | Sum. | Average. Vulg. | Average. Decimal. | Diameter. | Circumference. | Circumference Increment. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1877 | $\frac{13}{64}$ | $\frac{14}{64}$ | $\frac{13}{64}$ | $\frac{14}{64}$ | $\frac{54}{64}$ | $\frac{27}{64}$ | ·42 | 10·03 | 31·510248 | 1·319472 |
| 1878 | $\frac{17}{64}$ | $\frac{19}{64}$ | $\frac{18}{64}$ | $\frac{17}{64}$ | $\frac{71}{64}$ | $\frac{71}{128}$ | ·55 | 10·58 | 33·238128 | 1·727980 |
| 1879 | $\frac{13}{64}$ | $\frac{17}{64}$ | $\frac{16}{64}$ | $\frac{14}{64}$ | $\frac{60}{64}$ | $\frac{15}{32}$ | ·46 | 11·04 | 34·683264 | 1·445136 |
| 1880 | $\frac{16}{64}$ | $\frac{16}{64}$ | $\frac{16}{64}$ | $\frac{16}{64}$ | $\frac{64}{64}$ | $\frac{64}{128}$ | ·50 | 11·54 | 36·254064 | 1·570800 |
| 1881 | $\frac{14}{64}$ | $\frac{13}{64}$ | $\frac{14}{64}$ | $\frac{18}{64}$ | $\frac{59}{64}$ | $\frac{59}{128}$ | ·46 | 12·00 | 37·699200 | 1·445136 |
| 1882 | $\frac{17}{64}$ | $\frac{16}{64}$ | $\frac{17}{64}$ | $\frac{13}{64}$ | $\frac{63}{64}$ | $\frac{63}{128}$ | ·49 | 12·49 | 39·238584 | 1·539384 |
| 1883 | $\frac{14}{64}$ | $\frac{12}{64}$ | $\frac{13}{64}$ | $\frac{13}{64}$ | $\frac{52}{64}$ | $\frac{13}{32}$ | ·40 | 12·89 | 40·496224 | 1·256740 |
| 1884 | $\frac{18}{64}$ | $\frac{16}{64}$ | $\frac{14}{64}$ | $\frac{14}{64}$ | $\frac{62}{64}$ | $\frac{31}{64}$ | ·48 | 13·37 | 42·003192 | 1·507968 |
| 1885 | $\frac{17}{64}$ | $\frac{12}{64}$ | $\frac{12}{64}$ | $\frac{12}{64}$ | $\frac{53}{64}$ | $\frac{53}{128}$ | ·42 | 13·79 | 43·322664 | 1·319472 |
| 1886 | $\frac{16}{64}$ | $\frac{14}{64}$ | $\frac{10}{64}$ | $\frac{14}{64}$ | $\frac{54}{64}$ | $\frac{27}{64}$ | ·42 | 14·21 | 44·642136 | 1·319472 |
| 1887 | $\frac{20}{64}$ | $\frac{14}{64}$ | $\frac{9}{64}$ | $\frac{11}{64}$ | $\frac{54}{64}$ | $\frac{27}{64}$ | ·42 | 14·63 | 45·961608 | 1·319472 |
| 1888 | $\frac{12}{64}$ | $\frac{13}{64}$ | $\frac{8}{64}$ | $\frac{13}{64}$ | $\frac{46}{64}$ | $\frac{23}{64}$ | ·35 | 14·98 | 47·061168 | 1·099560 |
| 1889 | $\frac{14}{64}$ | $\frac{12}{64}$ | $\frac{8}{64}$ | $\frac{14}{64}$ | $\frac{48}{64}$ | $\frac{3}{8}$ | ·37 | 15·35 | 48·223560 | 1·162392 |
| 1890 | $\frac{13}{64}$ | $\frac{10}{64}$ | $\frac{8}{64}$ | $\frac{16}{64}$ | $\frac{47}{64}$ | $\frac{47}{128}$ | ·36 | 15·71 | 49·354536 | 1·130976 |
| 1891 | $\frac{11}{64}$ | $\frac{11}{64}$ | $\frac{4}{64}$ | $\frac{17}{64}$ | $\frac{43}{64}$ | $\frac{43}{128}$ | ·33 | 16·04 | 50·391264 | 1·036728 |
| 1892 | $\frac{11}{64}$ | $\frac{13}{64}$ | $\frac{8}{64}$ | $\frac{17}{64}$ | $\frac{49}{64}$ | $\frac{49}{128}$ | ·38 | 16·42 | 51·585072 | 1·193808 |
| 1893 | $\frac{17}{64}$ | $\frac{16}{64}$ | $\frac{14}{64}$ | $\frac{16}{64}$ | $\frac{63}{64}$ | $\frac{63}{128}$ | ·49 | 16·91 | 53·124456 | 1·539384 |
| 1894 | $\frac{12}{64}$ | $\frac{16}{64}$ | $\frac{15}{64}$ | $\frac{17}{64}$ | $\frac{60}{64}$ | $\frac{15}{32}$ | ·46 | 17·37 | 54·569592 | 1·445136 |
| 1895 | $\frac{13}{64}$ | $\frac{9}{64}$ | $\frac{13}{64}$ | $\frac{12}{64}$ | $\frac{47}{64}$ | $\frac{47}{128}$ | ·36 | 17·73 | 55·700568 | 1·130976 |
| 1896 | $\frac{2}{64}$ | $\frac{3}{64}$ | $\frac{6}{64}$ | $\frac{4}{64}$ | $\frac{15}{64}$ | $\frac{15}{128}$ | ·11 | 17·84 | 56·046144 | ·345576 |
| 1897 | $\frac{4}{64}$ | $\frac{5}{64}$ | $\frac{9}{64}$ | $\frac{4}{64}$ | $\frac{22}{64}$ | $\frac{11}{64}$ | ·17 | 18·01 | 56·580216 | ·534072 |
| 1898 | $\frac{6}{64}$ | $\frac{6}{64}$ | $\frac{11}{64}$ | $\frac{5}{64}$ | $\frac{28}{64}$ | $\frac{7}{32}$ | ·21 | 18·22 | 57·239952 | ·659736 |
| 1899 | $\frac{6}{64}$ | $\frac{4}{64}$ | $\frac{12}{64}$ | $\frac{6}{64}$ | $\frac{28}{64}$ | $\frac{7}{32}$ | ·21 | 18·43 | 57·899688 | ·659736 |
| .. | .. | .. | .. | .. | .. | .. | 8·82 | .. | .. | .. |

## CASTANEA, No. 4.

**Diam. Inct. for 28 years = 7·58. Diam. in 1899 = 28·5. Diam. in 1871 = 20·92.**

| Year. | N. | S. | E. | W. | Sum. | Average. | | Diameter. | Circumference. | Circumference Increment. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Vulg. | Decimal. | | | |
| 1872 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·41 | 21·33 | 67·010328 | 1·288056 |
| 1873 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·36 | 21·69 | 68·141304 | 1·130976 |
| 1874 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·21 | 21·90 | 68·801040 | ·659736 |
| 1875 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·39 | 22·29 | 70·026264 | 1·225224 |
| 1876 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·35 | 22·64 | 71·125824 | 1·099560 |
| 1877 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·35 | 22·99 | 72·225384 | 1·099560 |
| 1878 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·35 | 23·34 | 73·324944 | 1·099560 |
| 1879 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·33 | 23·67 | 74·361672 | 1·036728 |
| 1880 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·33 | 24·00 | 75·398400 | 1·036728 |
| 1881 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·32 | 24·32 | 76·403712 | 1·005312 |
| 1882 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·28 | 24·60 | 77·283360 | ·879648 |
| 1883 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·31 | 24·91 | 78·257256 | ·973896 |
| 1884 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·27 | 25·18 | 79·105488 | ·848232 |
| 1885 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·29 | 25·47 | 80·016552 | ·911064 |
| 1886 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·26 | 25·73 | 80·833368 | ·816816 |
| 1887 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·23 | 25·96 | 81·555936 | ·722568 |
| 1888 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·25 | 26·21 | 82·341336 | ·785400 |
| 1889 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·26 | 26·47 | 83·158152 | ·816816 |
| 1890 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·21 | 26·68 | 83·817888 | ·659736 |
| 1891 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·25 | 26·93 | 84·603288 | ·785400 |
| 1892 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·26 | 27·19 | 85·420104 | ·816816 |
| 1893 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·19 | 27·38 | 86·017008 | ·596904 |
| 1894 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·21 | 27·59 | 86·676744 | ·659736 |
| 1895 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·17 | 27·76 | 87·210816 | ·534072 |
| 1896 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·16 | 27·92 | 87·713472 | ·502656 |
| 1897 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·22 | 28·14 | 88·404624 | ·691152 |
| 1898 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·17 | 28·31 | 88·938696 | ·534072 |
| 1899 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·19 | 28·5 | 89·535600 | ·596904 |
| .. | .. | .. | .. | .. | .. | .. | 7·58 | .. | .. | .. |

## FAGUS, No. 7.

**Diam. Inct. in 14 years = 3 91. Diam. in 1899 = 30·92. Diam. in 1885 = 27·01.**

| Year. | N. | S. | E. | W. | Sum. | Average. | | Diameter. | Circumference. | Circumference Increment. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Vulg. | Decimal. | | | |
| 1886 | $\frac{9}{64}$ | $\frac{9}{64}$ | $\frac{6}{64}$ | $\frac{14}{64}$ | $\frac{38}{64}$ | $\frac{19}{64}$ | ·29 | 27·30 | 85·765680 | ·911064 |
| 1887 | $\frac{9}{64}$ | $\frac{14}{64}$ | $\frac{7}{64}$ | $\frac{14}{64}$ | $\frac{44}{64}$ | $\frac{11}{32}$ | ·34 | 27·64 | 86·833824 | 1·068144 |
| 1888 | $\frac{8}{64}$ | $\frac{8}{64}$ | $\frac{7}{64}$ | $\frac{13}{64}$ | $\frac{36}{64}$ | $\frac{9}{32}$ | ·28 | 27·92 | 87·713472 | ·879648 |
| 1889 | $\frac{8}{64}$ | $\frac{8}{64}$ | $\frac{7}{64}$ | $\frac{8}{64}$ | $\frac{31}{64}$ | $\frac{31}{128}$ | ·24 | 28·16 | 88·467456 | ·753984 |
| 1890 | $\frac{8}{64}$ | $\frac{12}{64}$ | $\frac{11}{64}$ | $\frac{8}{64}$ | $\frac{39}{64}$ | $\frac{39}{128}$ | ·30 | 28·46 | 89·409936 | ·942480 |
| 1891 | $\frac{8}{64}$ | $\frac{11}{64}$ | $\frac{11}{64}$ | $\frac{8}{64}$ | $\frac{38}{64}$ | $\frac{19}{64}$ | ·29 | 28·75 | 90·321000 | ·911064 |
| 1892 | $\frac{7}{64}$ | $\frac{11}{64}$ | $\frac{10}{64}$ | $\frac{9}{64}$ | $\frac{37}{64}$ | $\frac{37}{128}$ | ·28 | 29·03 | 91·200648 | ·879648 |
| 1893 | $\frac{6}{64}$ | $\frac{12}{64}$ | $\frac{9}{64}$ | $\frac{9}{64}$ | $\frac{36}{64}$ | $\frac{9}{32}$ | ·28 | 29·31 | 92·080296 | ·879648 |
| 1894 | $\frac{9}{64}$ | $\frac{12}{64}$ | $\frac{6}{64}$ | $\frac{9}{64}$ | $\frac{36}{64}$ | $\frac{9}{32}$ | ·28 | 29·59 | 92·959944 | ·879648 |
| 1895 | $\frac{9}{64}$ | $\frac{8}{64}$ | $\frac{5}{64}$ | $\frac{7}{64}$ | $\frac{29}{64}$ | $\frac{29}{128}$ | ·22 | 29·81 | 93·651096 | ·691152 |
| 1896 | $\frac{8}{64}$ | $\frac{10}{64}$ | $\frac{8}{64}$ | $\frac{8}{64}$ | $\frac{34}{64}$ | $\frac{17}{64}$ | ·26 | 30·07 | 94·467912 | ·816816 |
| 1897 | $\frac{6}{64}$ | $\frac{10}{64}$ | $\frac{8}{64}$ | $\frac{8}{64}$ | $\frac{32}{64}$ | $\frac{1}{4}$ | ·25 | 30·32 | 95·253312 | ·785400 |
| 1898 | $\frac{6}{64}$ | $\frac{10}{64}$ | $\frac{8}{64}$ | $\frac{10}{64}$ | $\frac{34}{64}$ | $\frac{17}{64}$ | ·26 | 30·58 | 96·070128 | ·816816 |
| 1899 | $\frac{6}{64}$ | $\frac{14}{64}$ | $\frac{10}{64}$ | $\frac{14}{64}$ | $\frac{44}{64}$ | $\frac{11}{32}$ | ·34 | 30·92 | 97·138272 | 1·068144 |
| .. | .. | .. | .. | .. | .. | .. | 3·91 | .. | .. | .. |

## FAGUS, No. 8.

Diam. Inct. for 14 years = 3·71. Diam. in 1899 = 26·4. Diam. in 1885 = 22·69.

| Year. | N. | S. | E. | W. | Sum. | Average. Vulg. | Average. Decimal. | Diameter. | Circumference. | Circumference Increment. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1886 | 6/64 | 5/64 | 11/64 | 10/64 | 32/64 | 1/4 | ·25 | 22·94 | 72·068304 | ·78.400 |
| 1887 | 6/64 | 5/64 | 10/64 | 9/64 | 30/64 | 15/64 | ·23 | 23·17 | 72·790872 | ·722568 |
| 1888 | 7/64 | 8/64 | 13/64 | 12/64 | 40/64 | 5/16 | ·31 | 23·48 | 73·764768 | ·973896 |
| 1889 | 6/64 | 9/64 | 14/64 | 11/64 | 40/64 | 5/16 | ·31 | 23·79 | 74·738664 | ·973896 |
| 1890 | 6/64 | 8/64 | 12/64 | 14/64 | 40/64 | 5/16 | ·31 | 24·10 | 75·712560 | ·973896 |
| 1891 | 6/64 | 7/64 | 14/64 | 9/64 | 36/64 | 9/32 | ·28 | 24·38 | 76·592208 | ·879648 |
| 1892 | 7/64 | 8/64 | 15/64 | 8/64 | 38/64 | 38/128 | ·30 | 24·68 | 77·534688 | ·942480 |
| 1893 | 6/64 | 7/64 | 15/64 | 9/64 | 37/64 | 37/128 | ·28 | 24·96 | 78·414336 | ·87 648 |
| 1894 | 5/64 | 8/64 | 12/64 | 5/64 | 30/64 | 15/64 | ·23 | 25·19 | 79·136904 | ·722568 |
| 1895 | 5/64 | 7/64 | 12/64 | 6/64 | 30/64 | 15/64 | ·23 | 25·42 | 79·859472 | ·722568 |
| 1896 | 7/64 | 6/64 | 13/64 | 12/64 | 38/64 | 38/128 | ·30 | 25·72 | 80·801952 | ·942480 |
| 1897 | 8/64 | 7/64 | 8/64 | 4/64 | 27/64 | 27/128 | ·21 | 25·93 | 81·461688 | ·659736 |
| 1898 | 8/64 | 6/64 | 8/64 | 5/64 | 27/64 | 27/128 | ·21 | 26·14 | 82·121424 | ·659736 |
| 1899 | 11/64 | 11/64 | 7/64 | 5/64 | 34/64 | 17/64 | ·26 | 26·4 | 82·938240 | ·816816 |
| .. | .. | .. | .. | .. | .. | .. | 3·71 | .. | .. | .. |

## FRAXINUS EXCELSIOR, No. 2.

Diam. Inct. for 12 years = 3·39. Diam. in 1900 = 6·8. Diam. in 1888 = 3·41.

| Year. | N. | S. | E. | W. | Sum. | Average. Vulg. | Average. Decimal. | Diameter. | Circumference. | Circumference Increment. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1889 | 9/64 | 14/64 | 10/64 | 9/64 | 42/64 | 21/64 | ·32 | 3·73 | 11·718168 | 1·105312 |
| 1890 | 9/64 | 12/64 | 11/64 | 9/64 | 41/64 | 41/128 | ·32 | 4·05 | 12·723480 | 1·005312 |
| 1891 | 9/64 | 12/64 | 11/64 | 14/64 | 46/64 | 23/64 | ·35 | 4·40 | 13·823040 | 1·099560 |
| 1892 | 8/64 | 13/64 | 13/64 | 11/64 | 45/64 | 45/128 | ·35 | 4·75 | 14·922600 | 1·099560 |
| 1893 | 10/64 | 13/64 | 12/64 | 12/64 | 47/64 | 47/128 | ·36 | 5·11 | 16·053576 | 1·130976 |
| 1894 | 12/64 | 14/64 | 13/64 | 13/64 | 52/64 | 13/32 | ·40 | 5·57 | 17·310216 | 1·256640 |
| 1895 | 9/64 | 13/64 | 12/64 | 12/64 | 46/64 | 23/64 | ·35 | 5·86 | 18·409776 | 1·199760 |
| 1896 | 6/64 | 8/64 | 8/64 | 5/64 | 27/64 | 27/128 | ·21 | 6·07 | 19·069512 | ·659736 |
| 1897 | 5/64 | 6/64 | 5/64 | 6/64 | 22/64 | 22/128 | ·17 | 6·24 | 19·603584 | ·534072 |
| 1898 | 4/64 | 5/64 | 4/64 | 3/64 | 16/64 | 1/8 | ·12 | 6·36 | 19·980576 | ·377092 |
| 1899 | 6/64 | 6/64 | 6/64 | 8/64 | 26/64 | 13/64 | ·20 | 6·56 | 20·608896 | ·628320 |
| 1900 | 8/64 | 7/64 | 8/64 | 8/64 | 31/64 | 31/128 | ·24 | 6·8 | 21·36288 | ·727392 |
| .. | .. | .. | .. | .. | .. | .. | 3·39 | .. | .. | .. |

## LIRIODENDRON, No. 6.

Diam. Inct. for 21 years = 3·17. Diam. in 1899 = 28. Diam. in 1878 = 24·83.

| Year. | N. | S. | E. | W. | Sum. | Average. Vulg. | Average. Decimal. | Diameter. | Circumference. | Circumference Increment. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1879 | $\frac{5}{64}$ | $\frac{9}{64}$ | $\frac{9}{64}$ | $\frac{5}{64}$ | $\frac{28}{64}$ | $\frac{7}{32}$ | ·21 | 25·04 | 78·665664 | ·659736 |
| 1880 | $\frac{4}{64}$ | $\frac{8}{64}$ | $\frac{8}{64}$ | $\frac{5}{64}$ | $\frac{25}{64}$ | $\frac{25}{128}$ | ·19 | 25·23 | 79·262568 | ·596904 |
| 1881 | $\frac{4}{64}$ | $\frac{7}{64}$ | $\frac{8}{64}$ | $\frac{3}{64}$ | $\frac{22}{64}$ | $\frac{11}{64}$ | ·17 | 25·40 | 79·796640 | ·534072 |
| 1882 | $\frac{4}{64}$ | $\frac{7}{64}$ | $\frac{6}{64}$ | $\frac{3}{64}$ | $\frac{20}{64}$ | $\frac{5}{32}$ | ·15 | 25·55 | 80·267880 | ·471240 |
| 1883 | $\frac{3}{64}$ | $\frac{7}{64}$ | $\frac{7}{64}$ | $\frac{4}{64}$ | $\frac{21}{64}$ | $\frac{21}{128}$ | ·16 | 25·71 | 80·770536 | ·502656 |
| 1884 | $\frac{4}{64}$ | $\frac{10}{64}$ | $\frac{7}{64}$ | $\frac{4}{64}$ | $\frac{25}{64}$ | $\frac{25}{128}$ | ·19 | 25·90 | 81·367440 | ·596904 |
| 1885 | $\frac{4}{64}$ | $\frac{4}{64}$ | $\frac{6}{64}$ | $\frac{4}{64}$ | $\frac{22}{64}$ | $\frac{11}{64}$ | ·17 | 26·07 | 81·901512 | ·534072 |
| 1886 | $\frac{4}{64}$ | $\frac{9}{64}$ | $\frac{6}{64}$ | $\frac{4}{64}$ | $\frac{23}{64}$ | $\frac{23}{128}$ | ·17 | 26·24 | 82·435584 | ·534072 |
| 1887 | $\frac{4}{64}$ | $\frac{10}{64}$ | $\frac{8}{64}$ | $\frac{5}{64}$ | $\frac{27}{64}$ | $\frac{27}{128}$ | ·21 | 26·45 | 83·095320 | ·659736 |
| 1888 | $\frac{4}{64}$ | $\frac{6}{64}$ | $\frac{6}{64}$ | $\frac{3}{64}$ | $\frac{17}{64}$ | $\frac{17}{128}$ | ·13 | 26·58 | 83·503728 | ·408408 |
| 1889 | $\frac{2}{64}$ | $\frac{5}{64}$ | $\frac{4}{64}$ | $\frac{3}{64}$ | $\frac{14}{64}$ | $\frac{7}{64}$ | ·1 | 26·68 | 83·817888 | ·314160 |
| 1890 | $\frac{3}{64}$ | $\frac{7}{64}$ | $\frac{8}{64}$ | $\frac{7}{64}$ | $\frac{25}{64}$ | $\frac{25}{128}$ | ·19 | 26·87 | 84·414792 | ·596904 |
| 1891 | $\frac{6}{64}$ | $\frac{7}{64}$ | $\frac{5}{64}$ | $\frac{4}{64}$ | $\frac{22}{64}$ | $\frac{11}{64}$ | ·17 | 27·04 | 84·948864 | ·534072 |
| 1892 | $\frac{3}{64}$ | $\frac{7}{64}$ | $\frac{5}{64}$ | $\frac{4}{64}$ | $\frac{18}{64}$ | $\frac{18}{128}$ | ·14 | 27·18 | 85·388688 | ·339824 |
| 1893 | $\frac{4}{64}$ | $\frac{8}{64}$ | $\frac{5}{64}$ | $\frac{4}{64}$ | $\frac{21}{64}$ | $\frac{21}{128}$ | ·16 | 27·34 | 85·891344 | ·502656 |
| 1894 | $\frac{4}{64}$ | $\frac{6}{64}$ | $\frac{5}{64}$ | $\frac{3}{64}$ | $\frac{18}{64}$ | $\frac{9}{64}$ | ·14 | 27·48 | 86·331168 | ·439824 |
| 1895 | $\frac{4}{64}$ | $\frac{6}{64}$ | $\frac{5}{64}$ | $\frac{4}{64}$ | $\frac{19}{64}$ | $\frac{19}{128}$ | ·14 | 27·62 | 86·770992 | ·439824 |
| 1896 | $\frac{3}{64}$ | $\frac{4}{64}$ | $\frac{5}{64}$ | $\frac{4}{64}$ | $\frac{16}{64}$ | $\frac{1}{8}$ | ·12 | 27·74 | 87·147984 | ·376992 |
| 1897 | $\frac{3}{64}$ | $\frac{2}{64}$ | $\frac{3}{64}$ | $\frac{1}{64}$ | $\frac{9}{64}$ | $\frac{9}{128}$ | ·07 | 27·81 | 87·367896 | ·219912 |
| 1898 | $\frac{1}{64}$ | $\frac{3}{64}$ | $\frac{4}{64}$ | $\frac{2}{64}$ | $\frac{10}{64}$ | $\frac{5}{64}$ | ·07 | 27·88 | 87·587808 | ·219912 |
| 1899 | $\frac{2}{64}$ | $\frac{4}{64}$ | $\frac{6}{64}$ | $\frac{4}{64}$ | $\frac{16}{64}$ | $\frac{1}{8}$ | ·12 | 28·0 | 87·964800 | ·376992 |
| .. | .. | .. | .. | .. | .. | .. | 3·17 | .. | .. | .. |

## QUERCUS CERRIS, No. 63.

**Diam. Inct. for 12 years = 2·05. Diam. in 1899 = 22·2. Diam. in 1887 = 20·15.**

| Years. | N. | S. | E. | W. | Sum. | Average. Vulg. | Average. Decimal. | Diameter. | Circumference. | Circumference Increment. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1888 | $\frac{5}{64}$ | $\frac{4}{64}$ | $\frac{6}{64}$ | $\frac{4}{64}$ | $\frac{19}{64}$ | $\frac{5}{32}$ | ·15 | 20·30 | 63·774480 | ·471240 |
| 1889 | $\frac{4}{64}$ | $\frac{4}{64}$ | $\frac{4}{64}$ | $\frac{4}{64}$ | $\frac{16}{64}$ | $\frac{1}{8}$ | ·12 | 20·42 | 64·151472 | ·376992 |
| 1890 | $\frac{6}{64}$ | $\frac{6}{64}$ | $\frac{6}{64}$ | $\frac{6}{64}$ | $\frac{24}{64}$ | $\frac{3}{16}$ | ·18 | 20·60 | 64·716960 | ·565488 |
| 1891 | $\frac{5}{64}$ | $\frac{5}{64}$ | $\frac{6}{64}$ | $\frac{4}{64}$ | $\frac{20}{64}$ | $\frac{5}{32}$ | ·15 | 20·75 | 65·188200 | ·471240 |
| 1892 | $\frac{5}{64}$ | $\frac{4}{64}$ | $\frac{6}{64}$ | $\frac{5}{64}$ | $\frac{20}{64}$ | $\frac{5}{32}$ | ·15 | 20·90 | 65·659440 | ·471240 |
| 1893 | $\frac{7}{64}$ | $\frac{6}{64}$ | $\frac{7}{64}$ | $\frac{6}{64}$ | $\frac{26}{64}$ | $\frac{13}{64}$ | ·20 | 21·10 | 66·287760 | ·628320 |
| 1894 | $\frac{7}{64}$ | $\frac{6}{64}$ | $\frac{7}{64}$ | $\frac{6}{64}$ | $\frac{26}{64}$ | $\frac{13}{64}$ | ·20 | 21·30 | 66·916080 | ·628320 |
| 1896 | $\frac{6}{64}$ | $\frac{4}{64}$ | $\frac{4}{64}$ | $\frac{6}{64}$ | $\frac{20}{64}$ | $\frac{5}{32}$ | ·15 | 21·45 | 67·387320 | ·471240 |
| 1896 | $\frac{7}{64}$ | $\frac{7}{64}$ | $\frac{8}{64}$ | $\frac{6}{64}$ | $\frac{28}{64}$ | $\frac{7}{32}$ | ·21 | 21·66 | 68·047056 | ·659736 |
| 1897 | $\frac{7}{64}$ | $\frac{6}{64}$ | $\frac{7}{64}$ | $\frac{7}{64}$ | $\frac{27}{64}$ | $\frac{27}{128}$ | ·21 | 21·87 | 68·706792 | ·659736 |
| 1898 | $\frac{5}{64}$ | $\frac{5}{64}$ | $\frac{6}{64}$ | $\frac{4}{64}$ | $\frac{20}{64}$ | $\frac{5}{32}$ | ·15 | 22·02 | 69·178032 | ·471240 |
| 1899 | $\frac{6}{64}$ | $\frac{6}{64}$ | $\frac{6}{64}$ | $\frac{6}{64}$ | $\frac{24}{64}$ | $\frac{3}{16}$ | ·18 | 22·2 | 69·743520 | ·565488 |
| .. | .. | .. | .. | .. | .. | .. | 2·05 | .. | .. | .. |

## QUERCUS CONFERTA, No. 54.

**Diam. Inct. for 12 years = 4·54. Diam. in 1899 = 14·5. Diam. in 1887 = 9·96.**

| Ye r. | N. | S. | E. | W. | Sum. | Average. Vulg. | Average. Decimal. | Diameter. | Circumference. | Circumference Increment. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1888 | $\frac{16}{64}$ | $\frac{12}{64}$ | $\frac{12}{64}$ | $\frac{16}{64}$ | $\frac{56}{64}$ | $\frac{7}{16}$ | ·43 | 10·39 | 32·641224 | 1·350888 |
| 1889 | $\frac{12}{64}$ | $\frac{14}{64}$ | $\frac{14}{64}$ | $\frac{12}{64}$ | $\frac{52}{64}$ | $\frac{13}{32}$ | ·40 | 10·79 | 33·897864 | 1·256640 |
| 1890 | $\frac{16}{64}$ | $\frac{22}{64}$ | $\frac{20}{64}$ | $\frac{22}{64}$ | $\frac{80}{64}$ | $\frac{5}{8}$ | ·62 | 11·41 | 35·845656 | 1·947792 |
| 1891 | $\frac{18}{64}$ | $\frac{14}{64}$ | $\frac{14}{64}$ | $\frac{18}{64}$ | $\frac{64}{64}$ | $\frac{1}{2}$ | ·50 | 11·91 | 37·416456 | 1·570800 |
| 1892 | $\frac{18}{64}$ | $\frac{15}{64}$ | $\frac{20}{64}$ | $\frac{15}{64}$ | $\frac{68}{64}$ | $\frac{17}{32}$ | ·53 | 12·44 | 39·081504 | 1·665048 |
| 1893 | $\frac{18}{64}$ | $\frac{18}{64}$ | $\frac{20}{64}$ | $\frac{18}{64}$ | $\frac{74}{64}$ | $\frac{37}{64}$ | ·57 | 13·01 | 40·872216 | 1·790712 |
| 1894 | $\frac{16}{64}$ | $\frac{16}{64}$ | $\frac{16}{64}$ | $\frac{8}{64}$ | $\frac{56}{64}$ | $\frac{7}{16}$ | ·43 | 13·44 | 42·223104 | 1·350888 |
| 1895 | $\frac{12}{64}$ | $\frac{6}{64}$ | $\frac{16}{64}$ | $\frac{10}{64}$ | $\frac{44}{64}$ | $\frac{11}{32}$ | ·34 | 13·78 | 43·291248 | 1·068144 |
| 1896 | $\frac{10}{64}$ | $\frac{16}{64}$ | $\frac{8}{64}$ | $\frac{4}{64}$ | $\frac{38}{64}$ | $\frac{19}{64}$ | ·29 | 14·07 | 44·202312 | ·911064 |
| 1897 | $\frac{4}{64}$ | $\frac{8}{64}$ | $\frac{5}{64}$ | $\frac{3}{64}$ | $\frac{20}{64}$ | $\frac{5}{32}$ | ·15 | 14·22 | 44·673552 | ·471240 |
| 1898 | $\frac{4}{64}$ | $\frac{4}{64}$ | $\frac{4}{64}$ | $\frac{3}{64}$ | $\frac{15}{64}$ | $\frac{15}{128}$ | ·11 | 14·33 | 45·019128 | ·345576 |
| 1899 | $\frac{3}{64}$ | $\frac{6}{64}$ | $\frac{8}{64}$ | $\frac{5}{64}$ | $\frac{22}{64}$ | $\frac{11}{64}$ | ·17 | 14·50 | 45·553200 | ·534072 |
| .. | .. | .. | .. | .. | .. | .. | 4·54 | .. | .. | .. |

## TILIA, No. 2.

Diam. Inct. for 20 years = 1·74. Diam. in 1899 = 26. Diam. in 1879 = 24·26.

| Year. | N. | S. | E. | W. | Sum. | Average. Vulg. | Average. Decimal. | Diameter. | Circumference. | Circumference Increment. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1880 | 5/64 | 3/64 | 5/64 | 3/64 | 16/64 | 1/8 | ·12 | 24·38 | 76·592208 | ·376992 |
| 1881 | 1/64 | 3/64 | 6/64 | 2/64 | 12/64 | 3/32 | ·09 | 24·47 | 76·874952 | ·282744 |
| 1882 | 3/64 | 3/64 | 6/64 | 1/64 | 13/64 | 13/128 | ·10 | 24·57 | 77·189112 | ·314160 |
| 1883 | 5/64 | 6/64 | 6/64 | 2/64 | 19/64 | 19/128 | ·14 | 24·71 | 77·628936 | ·439824 |
| 1884 | 3/64 | 4/64 | 3/64 | 3/64 | 13/64 | 13/128 | ·10 | 24·81 | 77·943096 | ·314160 |
| 1885 | 1/64 | 3/64 | 4/64 | 2/64 | 10/64 | 5/64 | ·07 | 24·88 | 78·163008 | ·219912 |
| 1886 | 1/64 | 3/64 | 3/64 | 3/64 | 10/64 | 5/64 | ·07 | 24·95 | 78·382920 | ·219912 |
| 1887 | 4/64 | 4/64 | 2/64 | 3/64 | 13/64 | 13/128 | ·10 | 25·05 | 78·697080 | ·314160 |
| 1888 | 1/64 | 3/64 | 2/64 | 2/64 | 8/64 | 1/16 | ·06 | 25·11 | 78·885576 | ·188496 |
| 1889 | 1/64 | 2/64 | 1/64 | 1/64 | 5/64 | 5/128 | ·03 | 25·14 | 78·979824 | ·094248 |
| 1890 | 1/64 | 2/64 | 3/64 | 3/64 | 9/64 | 9/128 | ·07 | 25·21 | 79·199736 | ·219912 |
| 1891 | 4/64 | 3/64 | 3/64 | 2/64 | 12/64 | 3/32 | ·09 | 25·30 | 79·482480 | ·282744 |
| 1892 | 4/64 | 4/64 | 2/64 | 4/64 | 14/64 | 7/64 | ·10 | 25·40 | 79·796640 | ·314160 |
| 1893 | 3/64 | 4/64 | 3/64 | 2/64 | 12/64 | 3/32 | ·09 | 25·49 | 80·079384 | ·282744 |
| 1894 | 5/64 | 4/64 | 2/64 | 4/64 | 15/64 | 15/128 | ·11 | 25·60· | 80·424960 | ·345576 |
| 1895 | 4/64 | 2/64 | 3/64 | 2/64 | 11/64 | 11/128 | ·08 | 25·68 | 80·676288 | ·251328 |
| 1896 | 4/64 | 3/64 | 3/64 | 2/64 | 12/64 | 3/32 | ·09 | 25·77 | 80·959032 | ·282744 |
| 1897 | 4/64 | 3/64 | 2/64 | 4/64 | 13/64 | 13/128 | ·10 | 25·87 | 81·273192 | ·314160 |
| 1898 | 2/64 | 4/64 | 2/64 | 4/64 | 12/64 | 3/32 | ·09 | 25·96 | 81·555936 | ·282744 |
| 1899 | 1/64 | 1/64 | 2/64 | 2/64 | 6/64 | 3/64 | ·04 | 26· | 81·681600 | ·125664 |
| .. | .. | .. | .. | .. | .. | .. | 1·74 | .. | .. | .. |

## TAXUS, No. 41.

Diam. Inct. for 28 years = 3·62. Diam. in 1899 = 24·4. Diam. in 1871 = 20·78.

| Year. | N. | S. | E. | W. | Sum. | Average. Vulg. | Average. Decimal. | Diameter. | Circumference. | Circumference Increment. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1872 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·17 | 20·95 | 65·81652 | ·534072 |
| 1873 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·15 | 21·10 | 66·28776 | ·47124 |
| 1874 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·15 | 21·25 | 66·75900 | ·47124 |
| 1875 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·12 | 21·37 | 67·135992 | ·376992 |
| 1876 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·12 | 21·49 | 67·512984 | ·376992 |
| 1877 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·12 | 21·61 | 67·889976 | ·376992 |
| 1878 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·15 | 21·76 | 68·361216 | ·471240 |
| 1879 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·13 | 21·89 | 68·769624 | ·408408 |
| 1880 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·14 | 22·03 | 69·209448 | ·439824 |
| 1881 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·12 | 22·15 | 69·586440 | ·376992 |
| 1882 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·14 | 22·29 | 70·026264 | ·439824 |
| 1883 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·14 | 22·43 | 70·466088 | ·439824 |
| 1884 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·17 | 22·60 | 71·000160 | ·534072 |
| 1885 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·13 | 22·73 | 71·408568 | ·408408 |
| 1886 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·14 | 22·87 | 71·848392 | ·439824 |
| 1887 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·11 | 22·98 | 72·193968 | ·345576 |
| 1888 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·12 | 23·10 | 72·570960 | ·376992 |
| 1889 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·16 | 23·26 | 73·073616 | ·502656 |
| 1890 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·15 | 23·41 | 73·544856 | ·471240 |
| 1891 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·13 | 23·54 | 73·953264 | ·408408 |
| 1892 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·10 | 23·64 | 74·267424 | ·314160 |
| 1893 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·13 | 23·77 | 74·675832 | ·408408 |
| 1894 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·13 | 23·90 | 75·084240 | ·408408 |
| 1895 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·10 | 24·00 | 75·398400 | ·314160 |
| 1896 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·12 | 24·12 | 75·775392 | ·376992 |
| 1897 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·11 | 24·23 | 76·120968 | ·345576 |
| 1898 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·10 | 24·33 | 76·435128 | ·314160 |
| 1899 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ·07 | 24·4 | 76·655040 | ·219912 |
| .. | .. | .. | .. | .. | .. | .. | 3·62 | .. | .. | .. |

## ULMUS MONTANA, No. 93.

Diam. Inct. for 15 years=7·16. Diam. in 1900=11. Diam. in 1885=3·84.

| Year. | N. | S. | E. | W. | Sum. | Average. | | Diameter. | Circumference. | Circumference Increment. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Vulg. | Decimal. | | | |
| 1886 | $\frac{14}{64}$ | $\frac{16}{64}$ | $\frac{19}{64}$ | $\frac{26}{64}$ | $\frac{75}{64}$ | $\frac{75}{128}$ | ·58 | 4·42 | 13·885872 | 1·822128 |
| 1887 | $\frac{13}{64}$ | $\frac{14}{64}$ | $\frac{18}{64}$ | $\frac{25}{64}$ | $\frac{70}{64}$ | $\frac{35}{64}$ | ·54 | 4·96 | 15·582336 | 1·696464 |
| 1888 | $\frac{16}{64}$ | $\frac{17}{64}$ | $\frac{16}{64}$ | $\frac{19}{64}$ | $\frac{68}{64}$ | $\frac{34}{64}$ | ·53 | 5·49 | 17·247384 | 1·665048 |
| 1889 | $\frac{20}{64}$ | $\frac{20}{64}$ | $\frac{21}{64}$ | $\frac{27}{64}$ | $\frac{88}{64}$ | $\frac{88}{128}$ | ·69 | 6·18 | 19·415088 | 2·167704 |
| 1890 | $\frac{20}{64}$ | $\frac{16}{64}$ | $\frac{20}{64}$ | $\frac{15}{64}$ | $\frac{71}{64}$ | $\frac{71}{128}$ | ·55 | 6·73 | 21·142968 | 1·727880 |
| 1891 | $\frac{22}{64}$ | $\frac{13}{64}$ | $\frac{14}{64}$ | $\frac{26}{64}$ | $\frac{75}{64}$ | $\frac{75}{128}$ | ·58 | 7·31 | 22·965096 | 1·822128 |
| 1892 | $\frac{18}{64}$ | $\frac{7}{64}$ | $\frac{18}{64}$ | $\frac{8}{64}$ | $\frac{56}{64}$ | $\frac{7}{16}$ | ·43 | 7·74 | 24·315984 | 1·349888 |
| 1893 | $\frac{22}{64}$ | $\frac{13}{64}$ | $\frac{17}{64}$ | $\frac{12}{64}$ | $\frac{64}{64}$ | $\frac{1}{2}$ | ·5 | 8·24 | 25·886784 | 1·570800 |
| 1894 | $\frac{16}{64}$ | $\frac{4}{64}$ | $\frac{18}{64}$ | $\frac{11}{64}$ | $\frac{49}{64}$ | $\frac{49}{128}$ | ·38 | 8·62 | 27·080592 | 1·193808 |
| 1895 | $\frac{26}{64}$ | $\frac{12}{64}$ | $\frac{19}{64}$ | $\frac{21}{64}$ | $\frac{78}{64}$ | $\frac{39}{128}$ | ·30 | 8·92 | 28·023072 | 0·942480 |
| 1896 | $\frac{32}{64}$ | $\frac{6}{64}$ | $\frac{18}{64}$ | $\frac{8}{64}$ | $\frac{64}{64}$ | $\frac{1}{2}$ | ·5 | 9·42 | 29·593872 | 1·570800 |
| 1897 | $\frac{22}{64}$ | $\frac{8}{64}$ | $\frac{11}{64}$ | $\frac{19}{64}$ | $\frac{60}{64}$ | $\frac{15}{32}$ | ·46 | 9·88 | 31·039008 | 1·445136 |
| 1898 | $\frac{10}{64}$ | $\frac{15}{64}$ | $\frac{11}{64}$ | $\frac{16}{64}$ | $\frac{52}{64}$ | $\frac{13}{32}$ | ·40 | 10·28 | 32·295648 | 1·256640 |
| 1899 | $\frac{17}{64}$ | $\frac{8}{64}$ | $\frac{12}{64}$ | $\frac{11}{64}$ | $\frac{48}{64}$ | $\frac{3}{8}$ | ·37 | 10·65 | 33·458040 | 1·162392 |
| 1900 | $\frac{20}{64}$ | $\frac{5}{64}$ | $\frac{16}{64}$ | $\frac{5}{64}$ | $\frac{46}{64}$ | $\frac{23}{64}$ | ·35 | 11·00 | 34·5576 | 1·099560 |
| .. | .. | .. | .. | .. | .. | .. | 7·16 | .. | .. | .. |

# Hints on Propagating Mistletoe from the Berry.[1]

BY

WILLIAM PAXTON.

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The best tree for growing mistletoe on is a young Siberian Crab, with a stem below branches of about four feet in height. Young apple-trees are suitable also, and, in general, soft-wooded trees, such as the rowan. The best time for sowing is spring, about April, and the berries must have been freshly gathered within a few days. There are male and female mistletoe plants, which must be grown near each other in order to produce berries on the female plant.

Select a branch of from one to two inches in diameter, with clean, smooth bark, free from roughness or inequalities of any kind; also free from little side twigs from which birds could pick the berries. No incision, scratch, or bruise is to be made on the surface of the bark. This is of the utmost importance.

Take the berry between the finger and thumb and gently squeeze out the seed on to the bark, throwing away the skin. The seed will readily adhere by the viscid substance which is contained in the berry. The seed should not be rubbed in any way, but simply placed on the branch. In a short time the gummy substance dries up, leaving the seed firmly adhering to the branch. Several seeds should be placed together, or near each other, as probably only one out of half-a-dozen will grow.

Shortly after the berries have been placed a young green process appears, which turns towards the bark, and ultimately fixes itself there by a disk, but a year will have to elapse before it can be seen whether the seedling will grow or not.

[1] As we receive frequently applications for information upon this subject, this note by Mr. William Paxton of Orchardton, Fountainhall Road, Edinburgh, an enthusiastic and successful cultivator of mistletoe, should be generally useful.—*Regius Keeper.*

[Notes, R.G.B., Edin., No. V, 1901.]

# Notes on Museum-Methods in use at the Royal Botanic Garden, Edinburgh.

BY

H. F. TAGG, F.L.S.,

ASSISTANT IN THE MUSEUM.

**With Plate III.**

## CONTENTS.

## INTRODUCTORY.

It has been the practice in preparing specimens for the Museum of the Royal Botanic Garden, Edinburgh, to endeavour to preserve as naturally as possible the form of the specimen, and to name, where such a course seemed to add to the educational value of the exhibit, the different organs and parts of the specimen. The object has been to facilitate a comparison by students of the specimens exhibited, with the descriptions in text-books and lecture-notes.

A specimen so prepared was exhibited at a meeting of the British Association in 1896, and again in 1901 at a meeting of the same Association some notes on the subject were submitted. Requests have since been received for fuller details; these and the frequent enquiries made by visitors to the Museum for information concerning the preservation of plants for exhibition in museums have prompted the following descriptions of the methods employed.

## PRESERVING.

### I. General.

In the process of preserving, two stages are to be distinguished—first, killing the plant; second, its subsequent permanent preservation. The method adopted for the latter stage is commonly made to accomplish the former also; the preservative at the same time kills. The two operations may, however, be separate and distinct, but in practice, with some few exceptions, it is not found an advantage to separate the killing and preserving processes, provided always that the preservative kills fairly quickly.

Any method which inhibits the action of putrefactive organisms will, in the simplest sense, preserve plant-structures. A preservative may, moreover, while preventing the grosser changes of

putrefaction, arrest also, to a certain extent, intrinsic decompositions following death. A preservative may alter also, harden, and render firm, or it may be render more soft, the consistency of the plant-tissues.

Upon the prevention of internal changes rests the retention of the natural colours, or, if these be destroyed, the prevention of the formation of discolouring products, while hardening, if it takes place before characters of form have been destroyed, fixes such characters permanently.

The hardening may be due to desiccation either in the air, as happens when specimens are dried, or by the dehydrating action of a liquid medium, or it may result from chemical changes in the plant-substances induced by the preserving medium employed.

Reviewing the results of many experiments, it is impossible to say of any one preserving method that it is the best; the choice of a method must rest not only upon a consideration of the general character of the specimen, but upon a consideration also of any special feature or character the preservation of which may be particularly desired. The separation of such characters into characters of colour and characters of form coincides with the separation of the methods of preserving into two groups—preserving by drying the specimen, and preserving by means of liquid preserving media,

Drying the plant has proved the only method at all satisfactory for preserving the colours of plants, but fails commonly when applied to the preservation of the natural form. Liquid preservatives are invaluable for the preservation of the form of plants, but their use involves a sacrifice of the natural colours.

Again, as preservatives of the form of plants all liquid media are not equally useful, and it is necessary to distinguish those preserving only the form and shape of the separate parts from those preserving also the relationships of the parts to one another. Expressed concretely, the separate leaves on a twig, their shape, substance, and form, may be well preserved in a given medium, but unless there is also preserved the correct angle at which the leaves stand out from the stem and their relationships to one another in leaf-symmetry, then the preservation of the form of the specimen is of a limited kind.

One has to distinguish, then, the preservation of the form of the parts and the preservation of the lie of the organs of the plant.[1]

## II. Methods.

The following is a convenient grouping of the methods of preserving here referred to :—

A. *In liquid media.*

1. ALCOHOLIC SOLUTIONS.

*a.* Alcohol 90 per cent.
*b.* Alcohol, 50 to 80 per cent.
*c.* Alcohol and Glycerine.
*d.* Synthol.

2. AQUEOUS SOLUTIONS.

*a.* Formaline.
*b.* Boric Acid.
*c.* Camphor-water.
*d.* Salicylic Acid.
*e.* Fluorides of Sodium.

B. *By drying.*

1. In Air.
2. In Sand.

I will deal with each of these separately:—

Of the alcoholic solutions, 90 per cent. alcohol is the one generally used, and of the aqueous, formaline. The other solutions referred to are some of the less-known preservatives which have occasionally proved useful.

[1] What we in Edinburgh have been in the habit of calling the "lie" of the organs has been termed by Professor Errera, in his report on experiments made at the Institute de Botanique, Brussels, "the attitude" of the specimen. In most of the literature of the subject when a medium is described as preserving well the natural form, the shape of the separate organs is only referred to.

## A. PRESERVING IN LIQUID MEDIA.

### 1. ALCOHOLIC SOLUTIONS.

*a. Alcohol 90 per cent.*

The alcohol commonly used is strong commercial methylated spirit about 90 per cent. and free from mineral naphtha. As obtained it is somewhat turbid and commonly of a slight brownish colour, and I find that specimens are stained if the preservative is used in this crude state. To prevent this, before being used the alcohol is rendered clear by distillation. The strength of the alcohol in the process is slightly raised, and varies after distillation from 91 to 95 per cent.

Such strong alcohol, perfectly clear, has been found to give by far the best results. It penetrates the tissues rapidly, quickly kills the protoplasm, and very readily hardens, the hardening being due to dehydration. As with other media, the usefulness varies with the class of specimen to be preserved.

### Class I.—Herbaceous Structures.

For herbaceous structures generally, leaves, tendrils, and nearly all flowers, alcohol proves of great value, but particularly so where the lie and symmetry of the organs as well as their shape and firmness are controlled by the turgescence of parenchyma-cells rather than by special strengthening tissues. Specimens of the kind killed and preserved in any of the aqueous media become flaccid and soft, and although the separate organs may retain their form, the relationships of the parts are not preserved. Killed in alcohol or by other methods and subsequently preserved in an aqueous medium the results are similar, but killed and also preserved in alcohol such specimens retain permanently the natural shape of the parts and the relationships of symmetry.

Not an unimportant factor in these results is the readiness with which alcohol wets the surface of the specimen, removing from surface-irregularities air, which, if allowed to remain, would interfere with the ready penetration of the medium. More important is its low specific gravity and its power of rapidly dehydrating. Placed in alcohol the specimen as a rule very slowly sinks: it is slightly heavier than the medium. This being so, the

loss of turgescence gradual, and the hardening of the specimen quick, little change of position of the organs results. Whereas when a specimen is placed in an aqueous medium it is from the first evident that the buoyancy of the parts tends greatly to distort its form.

*Method of Procedure.* — The specimen when gathered is immersed in the preservative before the least flagging or withering occurs. In many cases it is found necessary to carry the jar with the alcohol into the garden or plant-house, and to drop at once the specimen, as it is gathered, into the preservative. In the alcohol the specimen commonly as already stated slowly sinks, but if large quantities of air are present in the tissues it may at first float or only partially sink. It is undesirable that any part of the specimen should be left uncovered, and when the specimen does not of itself sink readily, either a small weight is attached to it by a silk thread to sink it, or it is fastened in some way to the glass support on which it is finally to be mounted and is thus held immersed.

The time taken to effect the hardening varies with the size and character of the specimen. With small specimens a few minutes will suffice; with others several hours will be required; but in all cases when once immersed the specimen should not be removed until it is completely hardened.

As the alcohol enters, the air present in the tissues is driven out, and any colouring substances present are at same time discharged and diffuse in the surrounding fluid. Chlorophyll if present is thus extracted as well as the colours of most flowers, the blue colour of some alone, being to a certain extent retained.

That the bleaching may prove satisfactory the jar containing the specimen is left in a position exposed to strong sunlight, which is most effective, aiding the discharge of the colouring substances and preventing the formation of discolouring decomposition-products, when the specimen is subjected to its action immediately after being immersed in the alcohol.

In the majority of cases chlorophyll is the colour-substance principally discharged. The chlorophyll-solution thus produced, if left exposed to sunlight, decomposes, and the spirit becomes almost clear, but it proves advantage, if well-bleached specimens are desired, to pour off this chlorophyll-solution as soon as the

specimen is properly hardened, and to substitute for it fresh clear spirit. This fresh spirit may become discoloured also, and so from time to time clear spirit must be substituted for that discoloured until a discharge of discolouring substances no longer takes place. The specimen, if then white, is ready for mounting ; if it be dark-coloured and a bleached specimen is required it is treated in one of the ways described below under Bleaching (p. 230).

## Class II.—Woody Objects.

Specimens of this kind appear to be equally well preserved in alcohol or in formaline, so that the choice of a preservative rests chiefly upon a consideration of the ultimate method of exhibition. If photoxylin is to be employed in the final mounting, alcohol is used ; if gelatine, then formaline is the preservative chosen.

## Class III.—Succulent Objects.

When the object to be preserved is bulky and contains relatively large quantities of water the dehydrating action of alcohol becomes a disadvantage. The quantity of water to be absorbed may be considerable, and its diffusion in the enveloping alcohol being comparatively slow, the specimen may come to be surrounded by an alcoholic solution of low percentage—too weak at first to have any hardening action on the tissues. The absorption of water from the specimen proceeding faster than the process of replacement by the alcohol, the unhardened external portions collapse and the specimen becomes wrinkled on the surface. If succulent specimens are to be preserved in alcohol they must first of all be placed in a weak solution (30 per cent.) and then slowly graded from this to alcohols of greater strength.

Sections of succulent fruits, and even of flowers and other specimens coming under Class I., contract somewhat on the cut surface, the amount of contraction varying with the area of cut surface and with the degree of succulence of the specimen. The curvatures that result may be counteracted if the section is kept flat between two pieces of glass. The section freshly cut is laid upon one piece of glass, a second piece is placed over it,

and the two are then firmly tied together with thin twine. The pieces of glass with the specimen thus secured between them are placed in the preservative and are allowed to remain there undisturbed until the specimen is completely hardened.

Alcohol being extremely volatile, it must always be kept in well sealed jars if its strength as a preservative is to be maintained. Regarding the one disadvantage attaching to its use—viz., the destruction of the natural colours—a compensating feature exists in the readiness with which it bleaches white the majority of specimens. Such bleaching, if the form of the specimen is well preserved, is perhaps more to be desired than the temporary or imperfect retention of colour to be secured in some cases by the use of formaline.

*b. Alcohol.—80 per cent., 70 per cent., 60 per cent.*

The lower percentages of alcohol are prepared by mixing with water the requisite amount of 90 per cent. alcohol after distillation.

The objection urged against aqueous media that they do not harden delicate specimens applies also to weak alcohol.

Experiments made with alcohols of varying degrees of strength go to show that while the weaker percentages may be employed with some success in preserving certain plants they possess even for these, with the exception of succulent specimens coming under Class III., no advantages over the 90 per cent. alcohol. For the great majority of specimens the weaker alcohol proves unsatisfactory, and the results of experiments with it show that where it is desirable to fix in the best manner possible the natural lie of the parts of a specimen it is not safe to employ alcohol of less strength than 90 per cent.

70 per cent. and 80 per cent. alcohols are useful, however, for the firmer and more woody specimens of Class II., while 50 per cent. alcohol or even 30 per cent. is valuable as a commencing medium for the more succulent specimens.

*c. Alcohol and Glycerine—90 per cent. Alcohol 50 c.c., and Glycerine 50 c.c.*

This has proved useful for the temporary preservation of material before dissection when the 90 per cent. alcohol alone would have made the material too brittle.

For softening material already hardened it is to be preferred generally to the 50 per cent. water-solution often employed for the purpose. The glycerine tends to keep the material pliable without exerting the macerating action that water under similar circumstances with delicate specimens is inclined to do.

It has been employed with some success for succulent specimens causing less contraction in such than alcohol does alone. For this purpose the following formula is used:—

| | |
|---|---|
| 90 per cent. Alcohol, . . | 50 c.c. |
| Water, . . . . . . | 50 c.c. |
| Glycerine, . . . . . | 50 c.c. |

*d. Synthol.*

Recently an alcoholic preparation called synthol has been recommended as a preservative for museum purposes.

It is claimed for it that it is a perfect substitute for absolute alcohol, and that it is an excellent dehydrating agent and a preservative of the first order.

From experiments I have made with it absolute synthol appears to act efficiently as a substitute for absolute alcohol.

For museum purposes, used undiluted, it penetrates and hardens delicate tissues rapidly and at the same time bleaches them as effectively as strong methylated alcohol. Diluted with water its action is less rapid, while the weaker percentages, as with alcohol proper, fail to harden. Photoxylin can be used with it as a mounting medium, but gelatine contracts and becomes opaque.

## 2. Aqueous Solutions.

*a. Formalin.*

Formol, formalin, formaline are commercial names for a 40 per cent. solution in water of formaldehyde, $CH_2O$. As a preservative the commercial preparation is used undiluted, or diluted with water to whatever extent required. The solutions which have been found most useful are—formalin 10 parts, water 90 parts; and formalin 15 parts, water 85 parts. Weaker solutions have been tried, but with them moulds in nearly all cases make their appearance on the surface of the fluid. The weaker solutions prove less reliable the larger the bulk of organic substance

to be preserved relative to the amount of fluid employed. A one per cent. solution will preserve plant-structures for a time, but ultimately moulds invade the preparation, and this happens relatively sooner if any part of the specimen be left exposed above the surface of the fluid. A point of importance is the deterioration of the fluid which in the course of time appears to a certain extent to take place. Formaldehyde gas is extremely volatile, and unless the jars containing the specimens are carefully sealed a weakening of the solution undoubtedly follows. From my experiments it appears that a deterioration may result—firstly, in consequence of the volatile nature of the formaldehyde gas, and secondly, as a result of changes and decompositions which it would seem take place in the presence of organic substances in the fluid itself. This being so, it is not surprising that the weaker solutions after a time permit the growth of moulds.

A note of interest in connection with the presence of acid substances in formalin is contributed by M. Trillat,[1] who points out that commercial formalin may contain as impurities acetic acid, formic acid, and pyroligneous products.

Formalin does not very readily wet the surface of plants, and penetration of the specimen by the liquid I have found to be in consequence comparatively slow. Until penetration is complete, and even for some time after, plants may retain to a certain extent their natural colours. The results of my experiments in this direction are as follows:—

### Formalin for Preservation of Natural Colours.

The red, yellow, and blue colours of flowers are better retained than they are in most other media; but the retention is not permanent. Red and yellow colours are retained longer than blue, but even red—the colour which has proved most permanent—ultimately fades or gives place to a brown if the jar containing the specimen is exposed to the light.

Formalin does not appear to extract chlorophyll, neither does it preserve the green colour, but exposed even to diffused light the chlorophyll is decomposed and the specimen assumes a dull brownish colour, or may, finally, be bleached quite white.

[1] Journ. de Pharm. (5), xxix., p. 537.

In the stronger solutions the fading of the colours is more rapid than in the weaker; but, as already stated, the disadvantage of the weaker solutions is that they permit the growth of moulds. If formalin is added to sea-water and the specimens are protected from the light the colours of marine algæ are fairly well preserved. These results are in agreement with most of the observations recorded.

White flowers may remain uncoloured, becoming nevertheless, as the fluid penetrates, more or less translucent, as may happen also with coloured flowers and other specimens, or they turn a dull brown colour.

The specimens which show this discolouration are, as a rule, such as would darken if preserved in alcohol; at the same time, according to Linsbauer,[1] *Lathræa squamaria, L.*, in formalin does not darken so badly as when it is preserved in alcohol, while, on the other hand, I find that specimens of some orchids which in alcohol brown only slightly become in formalin almost black. Formalin is used for many fungi, particularly the more succulent forms, and changes but little the colours of the darker and duller sorts.

## Formalin for Preservation of Plant-form.

Formalin fails to preserve the form of many specimens chiefly because it does not harden. Reference has already been made to this defect and to the soft and flaccid character of specimens of Class I. preserved in it. In the weaker (2 per cent.) solutions there is a tendency on the part of the petals of fragile and of fully expanded flowers to drop off after being a short time in the preservative. For succulent plants it presents the advantage that when preserved in it they do not to any extent contract.

For gelatinous or mucilaginous specimens it is valuable, causing little of the contraction and opacity which follow the immersion of such specimens in alcohol. Gelatinous bodies are hardened, swelling or slightly contracting according to the amount of absorbed water originally present. It is advisable to avoid formalin if the specimen to be preserved be one coated in

[1] Verhandl. der K.-K. Zoolog.—Bot. Gesellschaft in Wien, xliv. (1894), Sitz., p. 23.

any way with resin, for I find that the resin is coagulated and that it forms in such cases a white or grey covering over the resinous parts.

### Method of Procedure in using Formalin.

The density of the fluid makes it difficult to keep the specimen submerged, and methods such as were described for buoyant specimens in alcohol have usually to be resorted to.

Specimens with waxy coatings are before preservation in formalin immersed for a minute or two in strong alcohol to wet the surface. The alcohol is not allowed to enter the specimen or to act upon it sufficiently to cause contraction of the object; but if the surface be wetted in this way the specimen sinks more rapidly and the penetration of the formalin is facilitated.

### Formalin as a Preservative in Collecting.

As a preserving medium for use on excursions and in collecting, the concentrated form in which it can be carried makes it convenient,[1] this particularly so when collecting algæ, where the concentrated formalin is added to the water—sea-water or fresh water according to the habitat of the alga—in the tubes in which the specimens are placed. At the same time, Penzig[2] points out that when collecting abroad it is not so good as alcohol, because with formalin the tin cases commonly employed in work of the kind cannot be used, but glass bottles, heavy and inconvenient in transport, have to be resorted to.

*b. Boric Acid.*

This is recommended by Chalon[3] as one of the best of a large number of fluids he has tried for preserving botanical specimens. The solution used was a saturated or 3 per cent. aqueous solution, which was improved in some instances by adding 1 to 5 per cent. sodium sulphate.

I find the specimens, as with formalin, become flaccid, particularly those of Class I. Colours remain for some time, but fade when the specimens are exposed to light. Penetration is not very rapid, and there is difficulty at first in getting the specimens

[1] Hornell, Laboratorium et Museum, 1900, pp. 85-89.

[2] Laboratorium et Museum, 1901, p. 19.

[3] Bull. Soc. Roy. Bot. de Belge, xxxvi., Part 2, p. 39.

submerged. For some specimens of Classes II. and III., some tubers and bulbs, it has given good results, and it has, as Chalon points out, the advantage of being practically harmless to work with.

*c. Camphor-water.*

This is recommended by Setchell and Osterhout[1] for preserving large collections of algæ for several hours if they cannot be studied at once.

The method is to throw on to the surface of the sea-water in which they are left some chips of camphor-gum, which, though sparingly soluble, has powerful antiseptic properties.

On several occasions when collecting sea-weeds, at times when the usual preservatives have not been available, I have found that a liberal use of camphor will prevent the encroachment of putrefactive organisms for a considerable time, but beyond this I have had no experience with camphor as a preservative in museum work.

*d. Salicylic acid.*

A saturated solution is employed at times, but the preservative is little resorted to, as the specimens become flaccid and soft and in some cases much macerated. Chlorophyll and most other colours are destroyed although the formulæ following have given fair results in the special instances mentioned.

1. For fruits—the amount of glycerine to vary with their relative juiciness :—[2]
   1 oz. salicylic acid.
   5 gallons of water.
   a little glycerine.
2. For dark-coloured grapes :—
   1 oz. salicylic acid.
   8 oz. alcohol.
   2 gallons of water.

*e. Fluorides of Sodium.*

The fluorides of sodium, sodium-fluoride and sodium-bifluoride have been recommended as preserving fluids for plants and

[1] Bot. Gaz., xxi., 1896, p. 142.

[2] Bailey, Rule-book, p. 187.

animals.[1] Marpmann[2] has recommended sodium-fluoride, 2, 3, and 5 per cent. solutions in water. The bifluoride is also recommended. It possesses greater antiseptic properties than the fluoride. "It is not, in dilute solutions, directly poisonous, and so is pleasanter to work with than formol or sublimate."

I have made experiments with a number of solutions. In all cases the colours of plants fade or are destroyed. The plants become soft and flaccid, and in solutions of less than 10 per cent. fungi may appear on the surface of the fluid, and on the submerged material also.

The corroding action of the bifluoride on glass, even of comparatively weak solutions, prohibits its use as a final preservative in glass vessels.

## B. PRESERVING BY DRYING.

### I. DRYING IN AIR.

The following are the methods employed in dealing with the different classes of material mentioned.

*a.* Specimens of branches and twigs which are too large to be preserved in a fluid medium are dried by hanging them in a dry room, or, if the specimen is not too large, it is placed in a ventilated box to protect it from dust, or sand is run around it and the specimen dried in sand (*see* Drying in sand). Where the leaves are known to fall readily after drying the specimen is placed for a few minutes in boiling water before the drying process is commenced.

*b.* Specimens of woods and the like. Logs of wood which are to be dried and afterwards sawn or prepared as specimens of woods are placed in any dry well ventilated store. The drying should be slow and the temperature even. It is not enough that the store should be warm; unless well ventilated, the wood is liable to rot; again, if the drying is too rapid, the cracks produced are considerable. The logs are laid on their sides, freely exposing both cut ends. Where it is wished to preserve the bark, the logs are laid upon straw or brown paper. To keep free from cracks any special part of the bark I have found it an advantage to make longitudinal incisions at other parts of the circumference.

[1] Merck's Annual Report for 1899, p. 21.

[2] Marpmann, Zeitschrift fur angewandte Mikroskopie, 1899, p. 33. Centralblatt fur Bakteriologie und Parasitenkunde, 1899, Vol. 25, p. 309.

Cracks resulting from shrinkage then follow the lines initiated by the knife. Care should be taken to guard against the attacks of insects. Destructive forms are sometimes present in the logs when they are brought to the museum, and these should be searched for before the specimens are stored.

All dry specimens should be frequently examined, and any showing tunnellings of beetles or their larvæ should be promptly dealt with. If small enough they should be completely immersed in a poison solution. If this is impracticable they should be bathed or painted with the solution until it penetrates the borings completely. A poison solution I have found effective is the following:—

| | |
|---|---|
| Naphthalene, . . | 50 grms. |
| Corrosive sublimate, . | 5 grms. |
| Methylated alcohol, 90 per cent., . . . | 1000 c.c. |

Carbolic acid is sometimes added; an objection to its use is that it may stain the specimen somewhat.

*c.* Dry fruits, roots with mycorhizal coverings, wood attacked by fungi, fungi themselves—particularly the more hard and solid kinds—all dry fairly well. For the majority of these no special method is resorted to. They are suspended in a well ventilated room or are simply laid in an open or ventilated box until dry. Sometimes it is advisable to pin or otherwise fasten the parts in position to prevent warping while drying.

### 2. DRYING IN SAND.[1]

The method of drying in sand is followed in all cases where the preservation of the colours of flowers is of importance. Some flowers so dried retain their colour if protected from strong light, and certainly look well. Preservation of the form of the flower depends much on the skill of the operator. From the nature of the method considerable shrinkage takes place, and the process consequently is not adapted to the preservation of fleshy forms.

The method I have adopted is as follows:—

A cardboard or paper box, with folding sides is secured and

[1] Errera, Report of Brit. Ass. for Adv. Science, 1896, p. 685. Cornélis, Belgique horticole, 1880, p. 230.

the bottom covered with fine, clean, dry sand to the depth of about an inch. In this the flower to be preserved, from which previously all surface moisture has been removed, is adjusted by sticking the stalk in the sand and heaping the sand around, or in any way that best will facilitate the next operation. This consists of adding slowly more sand, building it up around the corolla, and pouring it into the centre of the flower and around the parts in such a way as not to alter the shape of the flower by the weight of the sand. This is continued until the flower is completely covered. The box is next placed over an ordinary sulphuric acid desiccator and the whole stood on a plate and under a glass bell-jar. The plate with the bell-jar is then placed on the hot-water pipes used for heating the building, or in an oven kept at a temperature of about 40° C. It is left undisturbed for a week or longer, when the box is taken out and the sand is carefully run off by folding down the sides. Considerable care must be exercised in handling flowers so dried, as they become extremely brittle. Any sand that adheres is removed by means of a soft brush or by letting sand fall in a gentle stream from some height upon the specimen. The falling grains, hitting those adhering to the specimen, dislodge them, but at the same time the height from which the sand falls should be adjusted so that the force of the falling sand is not sufficient to break the specimen. Flowers so dried may be kept in any well sealed vessel, provided there is also placed within the jar a small quantity of lime or other desiccator to absorb any moisture[1] contained in the jar.

I have found the cardboard box with folding sides easier to work with than the "cornet" of paper recommended as a receptacle for the specimen and sand during the drying process.

The weak points of the process appear in the shrinking of the parts that takes place, in the difficulty of preserving the natural shape perfectly, and in the impossibility of removing the sand from the nectar surfaces present in most flowers. The adhering of the sand to the cut surfaces makes impossible the

[1] Prof. Errara recommends a glass jar with a wide mouth, the hollow stopper of which is about two-thirds filled with lime kept in position by a piece of skin.

preservation of dissections which shall show the more minute structural features of flowers.

To prevent somewhat the adhering of the sand particles to the surface of the flower, the stirring of the sand with wax, such as a paraffin candle, so that each grain of sand comes to be covered with a thin coating of paraffin, has been recommended.[1]

## BLEACHING.

### 1. General.

The methods following apply particularly to material preserved in alcohol; they may be employed, however, with more or less success for specimens preserved in other media.

The subject for convenience will be considered under the following heads :—

A. Bleaching in 90 per cent. alcohol. The preservative in the case of material intended for alcohol is also the bleaching medium.

B. Bleaching treatment, before preserving, of material known to blacken in alcohol.

C. Bleaching of specimens already preserved, which have darkened under the action of the preservative.

Treatment of the specimens before preserving and likewise treatment after preserving are to be avoided when the simple treatment by alcohol alone can be made to give sufficiently good results.

The reasons for this are—first, treatment other than by alcohol alone has in a greater or less degree a softening and macerating action on the material bleached; and, second, such treatment tends, with an exception in the case of acid alcohol, to render the specimen flaccid. When special bleaching is, however, resorted to, better results are, as a rule, to be obtained by treating the specimens before preservation than can be secured by treatment subsequently of material already discoloured.

When it is known or supposed that a specimen will bleach in alcohol no special treatment is accorded it; if the

[1] Bailey, Rule-book, p. 187.

specimen is known to darken in alcohol it is treated before preservation; but if placed in alcohol without treatment and subsequently found to need bleaching it is treated by one of the methods given under C. It follows that a knowledge before preserving of the behaviour in alcohol of any particular specimen is a considerable aid in choosing the best method of procedure. No definite rules can be given, but the following statements afford some indication of the class of specimen for which bleaching other than by alcohol alone will generally be found to be necessary.

Specimens usually darkening in alcohol are those whose tissues contain large quantities of tannin, similarly also those in which much resin is present. Thick and leathery leaves and leaves with thick cuticles turn brown as a rule in alcohol, as do also flowers in which brown and yellow colours predominate White flowers, if fleshy and of a waxy appearance, frequently darken; if the petals are thin they commonly bleach well in alcohol. Leaves, stems, and other parts, of a light green colour bleach white, while those of a darker colour often do not. In the same way young tissues bleach better than older ones. Most seedlings bleach well, the exceptions being particularly some of the Ranunculaceæ and seedlings generally with slightly woody roots, for instance, palms and members of the Cupuliferæ.

Where I have found it possible to institute a comparison of the members of different families, I have found with certain exceptions that the Ranunculaceæ and Cupuliferæ among others stand out as orders the members of which do not readily bleach, while members of the Caryophylleæ, Cruciferæ, Leguminosæ, and Liliaceæ are commonly readily bleached in alcohol alone.

## II. Methods.

### A. BLEACHING IN 90 PER CENT. ALCOHOL.

Reference has already been made to the bleaching action of alcohol (page 219).

The essential points to be observed to secure success may bear repetition. They are:—

1. The immediate immersion of the material in the alcohol as soon as gathered.

2. The direct and immediate exposure of the jar containing the specimen to sunlight.
3. The employment of clean spirit only.

## B. BLEACHING BEFORE PRESERVING.

### I. PRELIMINARY AND RAPID KILLING

The darkening in alcohol of many specimens is prevented if they are first immersed in some rapidly acting killing agent. The most important of these are boiling water, boiling alcohol, and boiling acetic acid and alcohol.

*a. Boiling Water.*

The specimen is immersed in hot or even boiling water for from 1 to 5 minutes, or even, in the case of fleshy or solid specimens, for much longer. The length of time of immersion should vary with the character and consistency of the specimen. Subsequently the specimen is placed in alcohol and exposed to the action of sunlight.

The specimens become soft and flaccid during the process and harden subsequently in the alcohol. In the case of flowers the sap may aggregate below the epidermis in the form of blisters.

*b. Boiling Alcohol 90 per cent.*

This is employed in the same way as boiling water. The specimens are immersed for a varying time and are then transferred to normal 90 per cent. alcohol. Boiling alcohol penetrates more rapidly than does boiling water, but is not so effective, however, where much tannin is present, and, as with boiling water, blisters may form under the epidermis.

*c. Boiling Acetic Acid and Alcohol.*

| | |
|---|---|
| Acetic acid, . . . | 10 c.c. |
| Alcohol 90 per cent., . | 90 c.c. |

This penetrates rapidly. The macerating action is somewhat considerable if the treatment is other than momentary. Blisters may be produced as in the preceding cases. The bleaching which results is usually perfect.

## II. BY SOAKING BEFORE FINALLY PRESERVING IN SOLUTIONS WHICH PREVENT THE FORMATION OF DISCOLOURING SUBSTANCES.

1. Methods which do not render the specimen flaccid.

*a. Acid Alcohol.*[1]

The plants are placed in strong 90 per cent. alcohol, to which has been added 2 per cent. by volume of hydrochloric acid. They are then exposed as much as possible to sunlight. If the spirit becomes discoloured it is changed, clean acid alcohol being substituted for the discoloured spirit removed. When bleached the specimen is left in the acid alcohol permanently or it is transferred to ordinary non-acid alcohol. In the latter case some specimens exhibit a tendency to darken, but this discolouration is not so great as when the preliminary acid alcohol has been omitted.

The acid alcohol has a macerating action on delicate structures, and the subsequent handling of such is attended with some risk. It should be remembered also, when specimens bleached in this way are subsequently mounted, that photoxylin does not hold specimens to the mounting glass satisfactorily if any acid is present in the final preservative. Specimens, therefore, treated with acid alcohol should be washed free from acid in several changes of non-acid alcohol before being finally mounted if photoxylin is to be employed. Nitric acid and sulphuric acid have been used in the same way but with less success.

*b. Potassium Chlorate.*

Crystals of potassium chlorate are placed at the bottom of the jar containing the specimen and nitric or hydrochloric acid is added in small quantities, only sufficient to cover the crystals, by means of a pipette, precautions being taken to keep the acid from mixing with the spirit and from coming in direct contact with the specimen.

The chlorine liberated rises through the spirit and has a slight bleaching action. The process is not so effective as that given above.

[1] Hugo de Vries, Berichte du deutschen botanischen Gesellschaft, vii. 1889, p. 298.

2.—Methods which render the specimen flaccid.

*Dilute Acid Alcohol.*

| | |
|---|---|
| Alcohol 90 per cent., . . . . . | 40 c.c. |
| Water, . . . . . . . . | 50 c.c. |
| Hydrochloric acid or Nitric acid, . . | 10 c.c. |

The addition of water to the acid alcohol, while rendering the specimen soft, prevents to a great extent any subsequent browning of the specimen when transferred to 90 per cent. non-acid alcohol for final exhibition.

The specimen is either first immersed in 90 per cent. alcohol for a few minutes to wet the surface and then transferred to the dilute acid alcohol, or the fresh specimen is placed at once in the diluted solution. As in other cases, sunlight favours the bleaching. The macerating action is considerable, and the method should not be employed for delicate specimens. Where the specimens are less fragile and where boiling may be undesirable the results are usually good. Such a solution with nitric acid has been used with excellent results in the case of Musa, specimens of which, owing to the large quantities of tannin present in the tissues, are bleached with difficulty.

## C. BLEACHING AFTER PRESERVING.

Specimens which have darkened under the action of the preservative fall into two groups:—First, those we wish to keep hardened in alcohol; second, those which permit a transference to an aqueous medium, softening not being a disadvantage. The methods available in the former case are not so effective as those available in the latter.

1.—Methods which do not render the specimen flaccid.

For these the acid alcohol solution already described is, invariably used. The specimen is transferred to the acid alcohol and the jar exposed to sunlight. The bleaching is sometimes slow, is not always effective, and never so good as when the fresh specimen is placed at once in the acid alcohol before discolouration has taken place.

2.—Methods which render the specimen flaccid.

*a. Bleaching Solution.*

This is the most rapid and effective bleaching agent. Its macerating action is considerable, and it should not be employed when dealing with the more delicate specimens. The specimen is transferred from the strong alcohol and placed for several hours in alcohol of 50 per cent., from this it is transferred to water, and shortly after to a weak solution of ordinary bleaching powder. This solution is prepared by pouring warm water over bleaching powder and filtering.

After remaining in the bleaching solution for from 5 to 15 minutes, the specimen is transferred to a 2 per cent. by volume solution of hydrochloric acid in water. As the weak acid penetrates, it sets free the chlorine, which is thus brought into intimate contact with the substances to be bleached. If the specimen after some time is not sufficiently bleached it is replaced in the bleaching solution, and similarly a second time transferred to the acid. This is repeated as often as is necessary until bleaching is complete.

After bleaching, the specimen is placed in water, and from this it is graded to 90 per cent. alcohol.

The corresponding hypochlorites of sodium and potassium, "Eau de Labarraque" and "Eau de Javelle," are also powerful bleachers, breaking up on the addition of acid and setting free chlorine in the same manner as the hypochlorite of calcium. These also have a marked macerating action on the tissues.

*b. Warm Water and Acid.*

Nitric acid or hydrochloric acid 5 per cent.

The specimen is graded from the strong alcohol to water, and is from that transferred to a warm aqueous solution of hydrochloric acid or even to warm water alone.

After some hours it is again transferred by slow grading to strong alcohol and left to the action of sunlight.

The macerating is less than results from the employment of bleaching powder, but the bleaching is not so rapid.

## FIXING AND SUSPENDING THE SPECIMEN.

### I. General.

In the earliest preparations exhibited in round jars and bottles the specimen was simply placed in the jar, and where necessary loose parts were fastened together and delicate organs supported by tying the specimen with silk thread to glass rods, or the parts of a specimen were pinned together with thin glass rods. Or the specimen was simply suspended by silk thread from the cork or stopper of the jar. One or another or a combination of these methods was used as the requirements of the case seemed to dictate. In this way those morphological features of the specimen that it was desired to direct attention to were brought as much as possible to one side of the jar that they might be more easily seen and less distorted by the convex surface of the glass.

An advance upon this was the method of tying the specimens with silk thread to thin, almost transparent, sheets of mica. Holes were drilled in the mica with a needle and the thread tying the specimen was fastened behind. The mica possessed what proved a great advantage when circular jars were used, considerable flexibility. The mica-sheet was cut as wide or a little wider than the diameter of the jar, so that when placed in position within the jar the specimen attached to it was held by the flexible mica more or less to the one side of the jar and was thus readily seen. Commonly the mouth of the jar was smaller than the body, and in this case by carefully bending the mica a relatively large sheet could he introduced into a comparatively small-necked bottle.

These details are given as the methods are still sometimes resorted to, but as a rule at the present time the specimens are not tied but are fastened by some form of cement, while the adoption of the rectangular form of vessel, in connection with which the support for the specimen need not be flexible—indeed flexibility becomes a disadvantage—has led to mica being replaced by thin sheet glass.

The disadvantages of tying the specimen to the supporting glass are:—1. Great care must be exercised or the specimens are

injured, this particularly so in dealing with material already preserved. 2. The operation takes considerable time. 3. Specimens are liable to be cut through by the thread if they are at all heavy. 4. The thread tying the specimen is visible often, and detracts from the appearance of the preparation.

## II. Methods.

### I. CEMENTS FOR ATTACHING SPECIMENS TO MOUNTING GLASS.

#### A. CEMENTS USED WITH ALCOHOL.

1. *For light objects.*

Photoxylin is the cement invariably used with spirit material for light and small objects.

As obtained from Grubler of Leipzig it is a clear, slightly viscid fluid, and is ready without further preparation for use. The advantages attaching to its use are several. Specimens are quickly fastened to the support, and the operation involves little risk of injury to the preparation. Remaining transparent as the cement does, it is practically invisible. Its disadvantages are two. It can only be employed when the preservative used is strong alcohol, and it will not support heavy preparations.

The specimen to be mounted is taken from the alcohol in which it has been hardened and dehydrated, and the excess of surface alcohol is removed with filter paper or blotting paper. It is then placed in position on the glass or mica mount and a small quantity of photoxylin by means of a pipette is dropped upon it at the points at which it is to be fixed. The glass sheet with the specimen attached is then carefully laid in an open trough of 80 per cent. alcohol present in sufficient quantity to cover the specimen. It is left in this for about a minute. The photoxylin sets as a firm transparent jelly, and the mounting glass with the specimen fastened to it is now transferred to a vessel containing 90 per cent. alcohol. From this it may be moved to the exhibition jar containing 90 per cent. alcohol.

After the photoxylin has been applied it must be left to set in the air for a time, varying from a few seconds to as much as a minute, until in fact a slight film forms over its surface. If immersed in alcohol too soon the photoxylin is washed off and it

then congeals in shapeless masses on the surface of the fluid. On the other hand, the specimen removed from the preserving medium is in danger of drying, and a compromise has often to be made between the conflicting requirements of the cement and those of the specimen to be mounted.

2. *For heavy objects.*

Photoxylin will not support heavy specimens, so that resort is had in such cases to gelatine. It is extremely tenacious and will support specimens weighing several pounds if they are glued to the glass support at several points. In alcohol it becomes quite opaque, and its use is limited chiefly to those cases where the fastening cement is hidden behind the specimen. On a white background the cement, even if to a certain extent visible, is not conspicuous. On a black background its conspicuousness is lessened by mixing lamp black with it.

The cement is prepared as follows:—

Gelatine is soaked in water for several hours, the water not absorbed is then poured off and the gelatine heated over hot water. When melted, and of a fairly stiff consistency, it is ready for use.

The specimen should be dried to a certain extent, all excess of alcohol removed, and the glass plate upon which it is to be mounted should be dry and warm. This last condition is secured by holding the glass for a second or two over a gas flame. The cement, used hot, is applied to the specimen, and the latter laid upon the mounting glass so that the cement comes in contact with it and adheres to the warm surface. The cooling of the glass is hastened by running strong alcohol over the specimen from a pipette, which action serves the purpose also of preventing the specimen from drying. When the gelatine has cooled so as to be no longer in a fluid state, the glass plate with the specimen attached is placed in a bath of 90 per cent. alcohol. It is left in this for the gelatine to harden by dehydration, the specimen lying horizontally and putting little strain upon the cement holding it. When quite hardened, the glass with the specimen is lifted out and is transferred to the vessel in which the specimen is to be exhibited.

To fasten with gelatine delicate specimens which would be

liable to be dried by the method just described, resort is had in applying the cement to a pipette surrounded by a hot-water jacket which keeps the gelatine within the pipette in a liquid condition. The specimen is not taken out of the spirit, but is held in position in a dish or trough of alcohol at the bottom of which lies the sheet of glass the specimen is to be fastened to. The pipette, with the surrounding jacket, is brought so that the nose of the pipette touches the mounting glass at the bottom of the trough. Some of the gelatine is pressed out on to the glass and before it coagulates in the alcohol the specimen is placed upon it and is held in position until the gelatine is set firm.

### B. CEMENTS USED WITH FORMALIN.

1. *For light objects.*

For light objects, and where the gelatine will be seen, a clear jelly is made from the best French gelatine. The glass plate is warmed and the warm liquid gelatine dropped on the specimen at those points at which it is desired to fix it. It hardens in formalin and remains practically transparent, but readily takes up colouring matters if these have not previously been extracted from the specimen.

2. *For heavy objects.*

Gelatine is used for heavy objects where the cement is hidden behind the object mounted. The gelatine solution employed is the same as is used for heavy specimens in alcohol. The specimen should be dried as completely as possible. Where, as with formalin, the aqueous medium is not inflammable, the glass plate at the points where the cement rests may be heated slightly from below over a gas flame after the specimen has been laid in position

## II.—SUPPORTS FOR PREPARATIONS.

Mica is used for round jars, but for rectangular vessels thin sheet glass possesses many advantages. It is cheap, perfectly transparent, can be obtained in any size, and, being rigid, will support specimens of any weight. The mica sheets are of limited size, hardly transparent at the best, and if thin not sufficiently rigid. Opal and blue glass have been used as backgrounds but

not as mounting glasses. With clear glass any background can be used and several may be tried from which to select the best. If opal or blue glasses are used as the support of the specimen, the background becomes part of the preparation, and however unsuited it may subsequently prove cannot be varied. This becomes a disadvantage where the continued bleaching of a preparation already mounted, or its subsequent darkening, makes a change of background desirable.

Where a white or black background is desired, the back of the vessel may be painted the necessary colour. This proves effective, and the cost is considerably less than that which the employment of blue or opal glass as backgrounds involves.

## DESCRIPTIVE LABELS.

### I. General.

Long descriptive labels are rarely employed, but in every instance an effort is made to indicate concisely the point of biological interest the specimen illustrates.

To facilitate a comparison of the specimens exhibited with the descriptions of text books the names of the different organs are pointed out. This is done in one or the other of the following two ways:—The labels and pointers are attached so that the parts named are pointed out upon the specimen itself, or a photograph or drawing of the specimen is made, and the names of the parts are indicated upon this.

Where the character of the specimen permits its adoption the former method presents the advantage that in a direct manner a distinguishing name is associated with a given organ. The second method, however, where the drawing is made to a certain extent diagrammatic, allows a designated part to be more accurately indicated. Examples of the first method are shown in Plate III. Details of the way in which the method is carried out follow.

## II. Methods.

### I. LABELLING SPECIMENS PRESERVED IN ALCOHOL OR FORMALIN.

A difficulty which at first prevented the naming of the parts was the want of coloured pointers capable of being bent should the character of the specimen demand it, and which would moreover resist the action of the preserving medium. Thus copper wire, steel wire, and glass rods painted were tried with little success. In time the paint blistered and peeled off. I have now devised a method in which the colouring matter needed to make the pointer conspicuous is protected from the action of the preservative by being placed inside a fine capillary tube. The tubes are made by heating ordinary glass tubing of about $\frac{1}{4}$-inch bore, and when uniformly hot of a dull red colour at the point desired drawing it out to a fine capillary tube. This capillary tubing is broken into suitable lengths, and as required the tubes are filled with any colouring substance that may be considered effective and distinct upon the chosen background.

The backgrounds commonly used are either black or white, and upon these I use vermilion-coloured pointers

Ordinary moist colours mixed with melted gelatine are used to fill the tubes. The mixture, employed warm, flows up the tube for a certain length by capillarity. If pointers of a greater length are required the tubes are filled by means of a rubber pipette sucker fastened to one end of the tube by means of a clamp, or the sucker is held firmly around the tube with the finger and thumb of the left hand while with the right hand the air is expelled. When the rubber sucker is released the colour substance in which the free-end of the tube is steeped is drawn up and fills the tube.

Both the pointers and the labels in the case of specimens preserved in alcohol are attached with photoxylin : when the preservative is formalin they are fastened with the clear dilute gelatine already given as a cement for mounting light specimens in that medium.

### II. LABELLING DRY PREPARATIONS.

In the naming of the parts of dry preparations, the pointers used are the glass tubes already described, or pointers made of

copper wire painted with vermilion paint are employed. The labels and the pointers are attached with a gum made of equal parts of gum-tragacanth and gum-arabic or with the gelatine solution given on page 238.

### III. LABELLING MODELS.

The names of the parts of models are attached to pointers made of copper wire. Such pointers, in turn, are fastened to the parts to be named. The cement used for both operations has the following composition :—

Wax cement for attaching names to models.

Beeswax, $\frac{2}{3}$ parts.
Resin, 1 part.

The ingredients are melted together and the cement used warm.

At other times the wire used is pointed and the pointed end driven into the part of the model named. To a small piece of cork or pasteboard fastened at the free end of the wire the name-label is attached with gum or paste.

## LUTINGS FOR LIDS OF VESSELS.

### I. PERMANENT SEALING.

For permanently sealing the lids to museum jars I have found bichromated gelatine prepared as follows efficacious : —

1 oz. Nelson's Amber Gelatine is soaked in water for several hours ; the water not absorbed by the gelatine is then poured off and the gelatine melted over hot water. When melted, 5 grains. of bichromate of potash are added and the whole stirred.

The melted gelatine is applied with a pipette or glass rod to the rim of the vessel, and the lid, after it has been gently warmed over a Bunsen flame, is laid in position over the mouth of the jar. The gelatine should be fairly stiff; if too weak when the warm lid is laid on it may run down the inside of the vessel. When the lid has been placed in position, the cement is allowed to cool, and under the action of light it forms a luting insoluble in alcohol or water.

If the lid does not lie evenly on the rim of the vessel the contraction of the gelatine as it dries may crack the lid. To prevent this a cement with more body is prepared by mixing plaster of paris with the gelatine. The plaster fills the interstices between the lid and the rim of the jar. This plaster cement is applied warm in the same manner as the bichromated gelatine cement, excess of cement on the outside in both cases being cleaned off with a knife after it has cooled slightly.

## II. FIRM SEALING.

If a firm luting is required, but one which will afterwards permits the removal of the lid, a difficult matter when the lutings given above are employed, the following is used :—

Gelatine, 1 oz.
Paraffin wax, $\frac{1}{4}$ oz.

The gelatine is melted as described in the preceding case; to the melted gelatine the wax is added and also melted. The two are then beaten together vigorously so as to form as emulsion. The cement is used warm, a layer of the cement being placed on the rim of the vessel, and the lid as before warmed slightly before being placed in position.

## III. TEMPORARY SEALING.

For sealing lids temporarily, and as a luting when the jar is not likely to be handled, vaseline presents the advantage that it is clean and easily applied. It prevents, better than any other temporary luting I have tried, loss of spirit by evaporation and offers no difficulty to the ready removal of the lid should this become necessary.

Either of the first two cements may be used for sealing corked bottles. With spirit material the bichromated gelatine has given excellent results. The corks are dipped in the gelatine solution so as to coat them, and when the gelatine has set the corks are driven into the bottles flush with the top of the neck, or if fitting too tightly to permit this they are pared down flush with the top. Any alcohol present is carefully dried off and the surface of the cork covered with an even layer of cement.

If the jar is likely to be subjected to varying temperatures provision should be made for the expansion and contraction of the alcohol, and at the same time a means found by which the loss of spirit by evaporation—it is practically impossible altogether to prevent this—can be made good. Where the vessel is covered by a glass lid or disk a small hole is drilled in the lid, and this hole in turn is covered by an ordinary microscopic cover glass, luted down with vaseline. This permits expansion of the spirit, and relieves the pressure on the luting of the lid. The loss of alcohol that takes place is periodically made good, a small thistle funnel being used to introduce fresh alcohol into the vessel through the small hole provided. In the case of jars and bottles closed with corks, a hole is made in the centre of the cork and a glass tube of small diameter inserted. This takes the place and answers the purposes of the hole drilled in the glass disks.

## BUILDING UP OF GLASS VESSELS.

Many of the preparations in alcohol in the Museum are exhibited in vessels built up of pieces of plate-glass cemented together so as to form rectangular, spirit-proof boxes. These vessels are made as follows:—Pieces of plate-glass of good quality are cut the requisite sizes to form the sides and bottom of the vessel, and are then carefully ground along their edges, so that the component pieces, when the box is put together, will fit evenly against one another, leaving no cracks between the joints. A cement is prepared consisting of Nelson's amber gelatine, with bichromate of potash and plaster of paris. The gelatine is melted and the bichromate of potash and plaster of paris are subsequently added, and are stirred into a fairly firm and homogeneous cement which is used warm. A second cement is also prepared, composed of 1 oz. of Nelson's amber gelatine, 5 grains of bichromate of potash, and a few drops of glycerine. Each piece of glass is gently warmed, the plaster cement is applied evenly along the edges to be joined, and while the cement is still warm the glass is fitted in its place to form one of the sides or the bottom of the vessel as the case may be.

A definite order is observed in fitting the pieces together. First, the glass which is to be the back of the finished vessel is

laid flat on a table; the two sides are next cemented vertically right and left of the back glass; the third glass applied is that which is to be the bottom of the finished vessel; and finally the front glass is cemented in position.

When the plaster cement along the joints has cooled and has set firm enough to allow the vessel to be taken up and handled without risk of the pieces falling apart—this is usually after a few hours—the second cement, that without plaster of paris, is run as a luting around the inner angles of the vessel and is also applied as a thin layer over the outside joints. That this may be done successfully the second cement should not be very stiff. Both cements should be applied as evenly as possible, as the subsequent scraping and cutting away of any surplus cement weakens the joints and militates much against the success of the work.

The vessel is placed in a cool room and the cement allowed slowly to dry for one or two days, after which it is placed in strong sunlight until quite dry and until the gelatine under the action of the light has turned a brownish colour. It is perhaps premature to speak of the vessels so made as permanent, but there are in our Museum vessels which were built up thus five years ago which are to-day perfectly spirit-tight.

Much handling of the vessels would appear to be harmful, for some preparations which have been frequently moved have subsequently leaked, and it should be noted, too, that the strength of the spirit within the vessel should be maintained at 90 per cent. if the vessel is to be kept spirit-proof. The alternate drying and wetting of the cement consequent upon an intermittant use of a vessel also causes the cement in course of time to give way and the vessel to leak. Plate-glass or heavy sheet-glass is used, as I find that the thinner sheet-glass is liable to crack under the binding strain it is subjected to as the cement dries and contracts.

The perfectly plane surface of the plate-glass, and the fact that a vessel can be made any required size, are the great advantages of the method, but owing to the cost of the ground plate-glass and labour of grinding the edges square, vessels so made are not cheaper than the cast-glass rectangular vessels to be obtained at the present day.

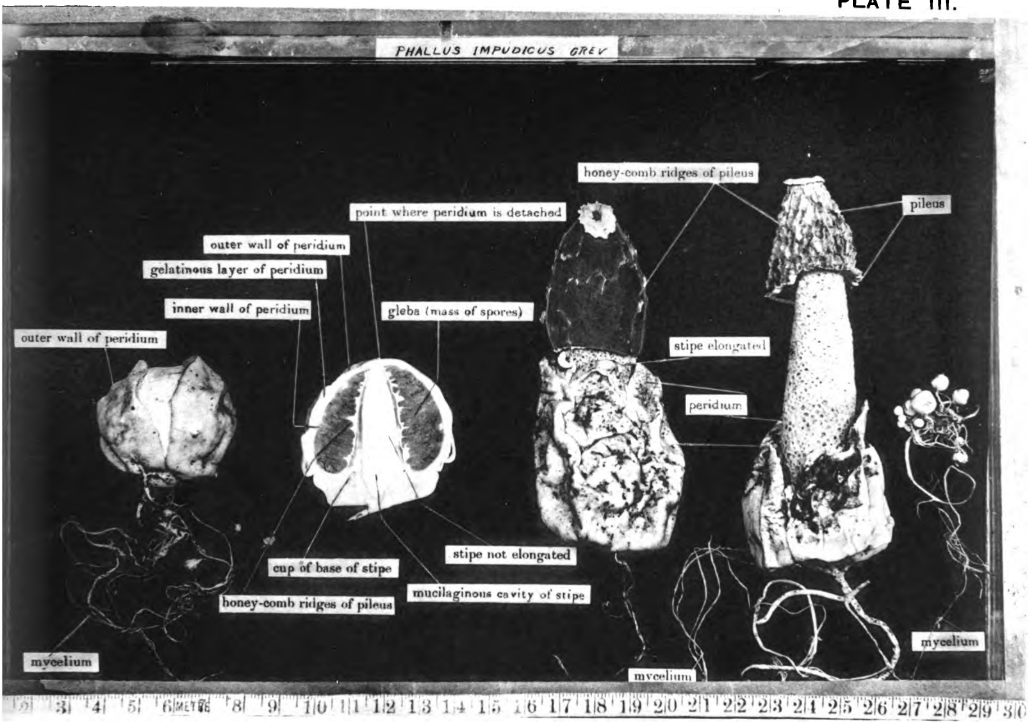
## Explanation of the Figures in Plate III.

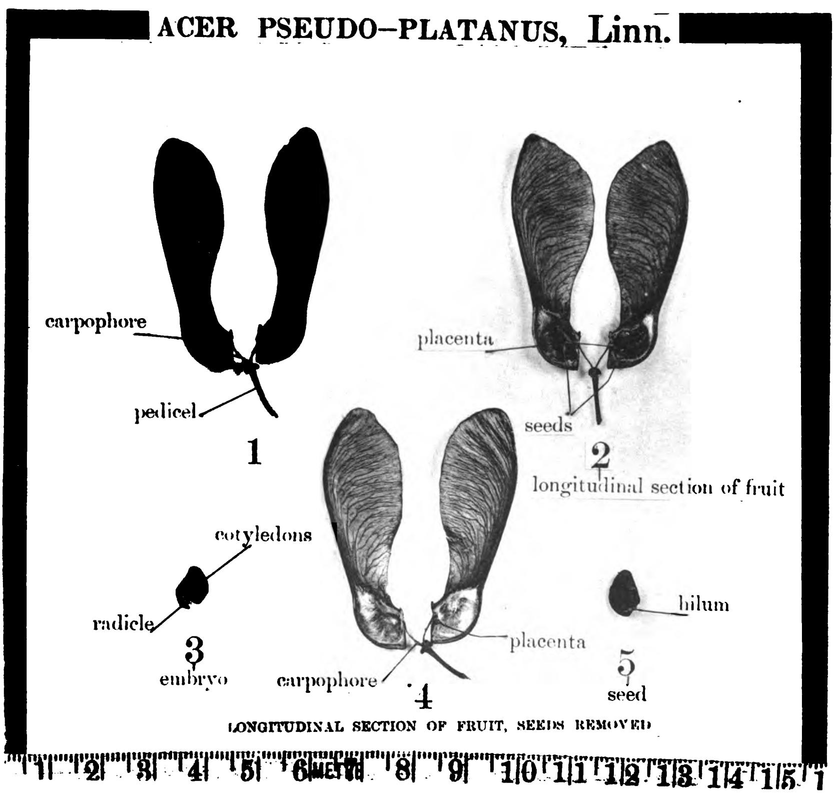
THE FIGURES ARE FROM PHOTOGRAPHS BY MR. T. W. WEST.

Upper figure:—Preparation in 90 per cent. alcohol, exhibited in a rectangular glass vessel. The back of the vessel is painted black, and the names of the parts are attached to a clear glass mount, to which, also, the specimens are fastened. The parts named are pointed out by means of thin glass tubes filled with vermilion injection medium.

Lower figure:—Dry preparation mounted on white card and enclosed in box with glass lid and sides. The small pointers are made of thin copper wire painted with vermilion oil colour.

The scale at the foot of the preparations has been added temporarily to serve as an index to the size of the specimens.


PHALLUS IMPUDICUS GREV
honey-comb ridges of pileus
pileus
point where peridium is detached
outer wall of peridium
gelatinous layer of peridium
inner wall of peridium
gleba (mass of spores)
outer wall of peridium
stipe elongated
peridium
stipe not elongated
cup of base of stipe
mucilaginous cavity of stipe
honey-comb ridges of pileus
mycelium
mycelium
mycelium


ACER PSEUDO-PLATANUS, Linn.
carpophore
pedicel
1
placenta
seeds
2
longitudinal section of fruit
cotyledons
radicle
3
embryo
hilum
placenta
carpophore
4
5
seed
LONGITUDINAL SECTION OF FRUIT, SEEDS REMOVED